

Scientific and Medical Books, and all objects of Natural History.
A. E. FOOTE, M. D.,
1223 Belmont Ave.,
Philadelphia, Pa.

MEDICAL.

VELPEAU'S ILLUSTRATED MIDWIFERY. Fifth American from the last French edition, with numerous additions and illustrations, by Prof. C. D. Meigs and W. Byrd Page, M.D. 8vo., sheep, ... $3

CAZEAUX'S MIDWIFERY, including the Diseases of Pregnancy and Parturition. 116 illustrations. 8vo., sheep, ... 3

☞ This work has received the almost universal commendation of the Medical Press and Profession of this country.

CRAIGE'S GENERAL AND PATHOLOGICAL ANATOMY. Royal 8vo., . . 3

MEIGS' PRACTICAL TREATISE ON THE DISEASES OF CHILDREN. Second edition, much enlarged. 8vo., sheep, ... 3

MENDENHALL'S MEDICAL STUDENT'S VADE-MECUM. Being a Compendium of Anatomy, Surgery, the Practice of Medicine, &c., &c. The Third edition, enlarged, with numerous illustrations. Royal 12mo, ... 2

WALTON'S OPERATIVE OPHTHALMIC SURGERY. 167 illustrations. 8vo., . 3

HEADLAND'S TREATISE ON THE ACTION OF MEDICINES IN THE SYSTEM. 8vo., ... 1

THE PHYSICIAN'S VISITING LIST, DAY-BOOK, AND MEMORANDA, published each year, for twenty-five patients. Cloth, 50 cents; tucks, 75; pencils, 75. Ditto, for fifty patients. Cloth, 75 cents; tucks, ... 1

A GERMAN-ENGLISH AND ENGLISH-GERMAN CLINICAL PHRASE-BOOK; or, Conversation between Physician and Patient, intended for Hospital, Dispensary, and Private Practice. By Montgomery Johns, M.D. 18mo., ... 1

HENLE'S TREATISE ON GENERAL PATHOLOGY. Translated by H. C. Preston, M.D. 1 vol., 8vo., ... 3

STILLE'S ELEMENTS OF GENERAL PATHOLOGY. 1 vol., ... 1

TUCKER'S PRINCIPLES AND PRACTICE OF MIDWIFERY. 1

BARTH AND ROGERS'S MANUAL OF AUSCULTATION AND PERCUSSION, .

REESE'S ANALYSIS OF PHYSIOLOGY. A new and enlarged edition, . . 1

MURPHY'S REVIEW OF CHEMISTRY FOR STUDENTS, ... 1

BIDDLES' R... STU-
DENT'S 1

HASTING'S 143

illustra 1

MACKINTOS 3

LECTURES (. . . . .

COXE'S EPI 2

MORRIS'S L . . . . .

SIMPSON ON . . . . HD-

WIFEL 1

COMFORT'S ' 3

REESE'S AM . . . . ties

and Us 1

BEASLEY'S . . . . OR-

MULA 1

BEASLEY'S . . . . Sy-

nopsis 1

Dit 1

THE PHYSICIAN'S POCKET PRESCRIPTION-BOOK, containing Lists of Terms, Phrases, Abbreviations, &c., &c. Cloth, 63 cents. Ditto, tucks, . . .

WYTHE'S POCKET DOSE AND SYMPTOM BOOK. Cloth, 63 cts. Do. tucks, .

THE AMERICAN JOURNAL OF PHARMACY. Published by authority of the Philadelphia College of Pharmacy. 6 numbers. Per annum, . . 3

SURGEON GENERAL'S OFFICE
LIBRARY.
Section,
No. 123797.

PERIODICALS.

RANKING'S HALF-YEARLY ABSTRACT OF THE MEDICAL SCIENCES. 8 volumes, sheep, per vol., $2 00. 16 numbers, paper, per no., . . .
Published half-yearly, in February and August, per annum. . . . 2
To mail subscribers, postage prepaid, when paid for in advance.

THE BRITISH AND FOREIGN MEDICAL REVIEW. London edition. Quarterly. Per annum, ... 5

1.25

THE MICROSCOPIST.

SURGEON GENERAL'S LIBRARY

THE CURIOSITIES OF THE MICROSCOPE;

OR,

ILLUSTRATIONS OF MINUTE PARTS OF CREATION.

WITH

NUMEROUS ILLUSTRATIONS.

BY THE REV. JOSEPH H. WYTHES, M.D.

AUTHOR OF "THE MICROSCOPIST," ETC., ETC.

"Every grain of sand is an immensity—every leaf a world."—LAVATER.

A neat 16mo. volume. Cloth, gilt, $1 00.

"This is a beautiful little book—beautiful in its printing, its colored plates, and its whole getting up, and is well adapted to instruct and amuse those for whom it is intended. There are twelve plates, containing numerous figures, drawn with much care, even to minute details. The spirit of the work is excellent, and we wish it in the hands of all the children of the land."—*Silliman's Journal.*

"It communicates substantial knowledge in the most entertaining way, and opens to the young intellect the whole subject of natural philosophy. The colored engravings greatly illustrate these instructions. We have seen no book written for young people that we can more cordially recommend."—*Christian Advocate and Journal.*

"The revelations of the microscope are truly astonishing; and the effort to unveil the minute parts of creation visible to youthful eyes by its amazing power, is worthy of praise. The style of this volume is adapted to the class for which it is prepared; and the numerous illustrations, beautifully colored, not only add to its beauty, but also to its usefulness."—*Recorder.*

"The style of the book is simple, yet comprehensive; and there are few men and women who will not, as well as the young, find pleasure and instruction in its pages. The colored plates, showing the appearance of a variety of things, animate and inanimate, as they appear when subjected to the microscope, are well executed, and form not the least attractive feature in the volume."—*Home Gazette.*

"For children who have any germs of a taste for scientific investigations, this little book would be highly attractive, and would encourage in all whom curiosity might tempt to its perusal, that love of Nature which forms one of the purest and richest sources of pleasure through life."—*Saturday Post.*

"No more beautiful present can be given to our children, nor one better calculated to enlarge their views of the wonders of creation. It will also furnish much knowledge to children of a larger growth."—*State Banner.*

LINDSAY & BLAKISTON,
Publishers.



FIG. 1.



FIG. 2.



FIG. 3.



FIG. II.

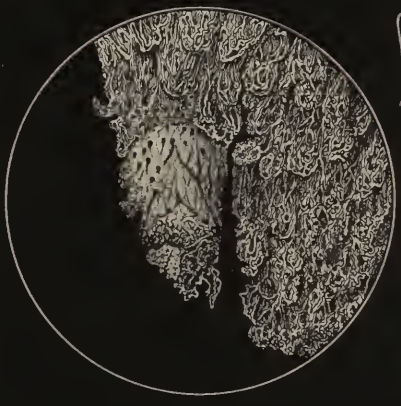


FIG. 4.

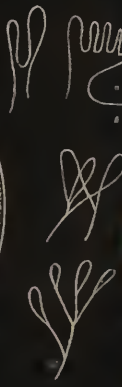




FIG. 5.

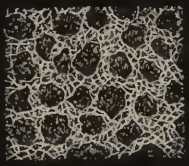


FIG. 6.

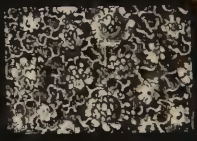


FIG. 7.



FIG. 8.



FIG. 9.



FIG. 10.

THE

MICROSCOPIST;

OR,

A Complete Manual

ON THE

USE OF THE MICROSCOPE:

FOR

PHYSICIANS, STUDENTS,

AND ALL

LOVERS OF NATURAL SCIENCE.

SECOND EDITION, IMPROVED AND ENLARGED.

WITH ILLUSTRATIONS.

BY

JOSEPH H. WYTHES, M.D.

123797

PHILADELPHIA:
LINDSAY AND BLAKISTON.
LONDON:
TRUBNER & CO.
1853.

QH
W99Gn
1853

Entered, according to Act of Congress, in the year 1853,

BY LINDSAY AND BLAKISTON,

In the Clerk's Office of the District Court for the Eastern District of Pennsylvania.

C. SHERMAN, PRINTER.

TO

PAUL BECK GODDARD, M.D.,

DISTINGUISHED BY

HIS ARDENT AND SUCCESSFUL PROSECUTION

OF

THIS AND KINDRED STUDIES,

This Work

IS RESPECTFULLY INSCRIBED

BY

THE AUTHOR.

PREFACE

TO THE SECOND EDITION.

THE rapid sale of the first edition of this work, both in England and the United States, proves its adaptation to the wants of the scientific community, and justifies the care and extra expense with which this second edition has been prepared.

Although the first edition was unusually large, it is not at all probable that the demand has been exhausted. But a little more than a year has elapsed since its appearance, yet sufficient time has been afforded for the author to make a number of important additions, which increase the value of the work to the student of nature.

The facts relating to microscopic science are not the result of one man's labors, or of a single generation, but have been gradually accumulating for many years; yet at the present the number of indefatigable observers is very considerable, and the author is presumptuous enough to think that the preparation of this manual has increased that number, by diminishing the difficulty of the study, and pointing out the most judicious methods of observation.

For the flattering notice taken of this work by the medical and scientific journals, the author is under many obligations, many prominent periodicals having spoken of it in terms of the highest praise.

It has formed no part of the design of this book to describe the mechanical arrangements of different instrument-makers; yet sufficient directions have been given to enable any one possessed of a microscope, of any mechanical form and arrangement, to use it to the best advantage. Whatever be the favorite pursuit of the student, whether Botany, Zoology, Anatomy, Physiology, or Pathology, the present manual gives information, by means of which the microscope may be profitably employed. In addition to this, the chapters on Minute Dissection, Injection, &c., will be of interest to many.

CONTENTS.

		PAGE
CHAPTER I.	THE HISTORY AND IMPORTANCE OF MICROSCOPIC INVESTIGATION,	13
II.	THE MICROSCOPE,	22
III.	ADJUNCTS TO THE MICROSCOPE,	41
IV.	HOW TO USE THE MICROSCOPE,	51
V.	ON MOUNTING AND PRESERVING OBJECTS FOR EXAMINATION,	55
VI.	ON PROCURING OBJECTS FOR THE MICROSCOPE,	67
VII.	TEST OBJECTS,	110
VIII.	ON DISSECTING OBJECTS FOR THE MICROSCOPE,	118
IX.	THE CELL-DOCTRINE OF PHYSIOLOGY,	129
X.	EXAMINATION OF MORBID STRUCTURES, ETC.,	139
XI.	ON MINUTE INJECTIONS,	158
XII.	EXAMINATION OF URINARY DEPOSITS,	169
XIII.	ON POLARIZED LIGHT,	188
XIV.	MISCELLANEOUS HINTS TO MICROSCOPISTS,	196

THE MICROSCOPIST.

CHAPTER I.

THE HISTORY AND IMPORTANCE OF MICROSCOPIC INVESTIGATION.

From the earliest period of scientific research, the magnifying properties of lenses have been used to penetrate the arcana of nature, and with most striking results. A vast amount of information, which could have been obtained in no other way, has been added, by microscopic observation, to almost every branch of natural science.

To the Christian philosopher, the microscope reveals the most amazing evidence of that Creative Power and Wisdom before which great and small are terms without meaning. He rises from the contemplation of the minutiæ which it displays, feeling more strongly than ever the force of those beautiful words—"If God so clothe the grass of the field, which to-day is, and to-morrow is cast into the oven, shall he not much more clothe you? O ye of little faith!"

To the geologist, it reveals the striking, yet humbling fact, that the world on which we tread is but the wreck of ancient

organic creations. The large coal beds are the ruins of a luxuriant and gigantic vegetation; and the vast limestone rocks, which are so abundant on the earth's surface, are the catacombs of myriads of animal tribes which are too minute to be perceived by the unassisted vision. It exhibits, also, that metallic ore, as the Bog Iron Ore, and immense layers of earthy and rocky matter, are formed merely by the aggregation of the skeletons or shields of Infusoria; while beds of coral rocks are still in the process of formation, the architects being tiny marine polypi. Further, by this instrument, the nature of gigantic fossil remains is often determined, and by it they are assigned their true place in the classification of the naturalist.

To the student of vegetable physiology, the microscope is an indispensable instrument. By it he is enabled to trace the first beginnings of vegetable life, and the function of the different tissues and vessels in plants.

The zoologist finds it also a necessary auxiliary. Without it, not only would the structure and functions of many animals remain unknown, but the existence of numerous species would be undiscovered.

It is to the medical student and practitioner, however, that the microscope especially commends itself for its utility. A new branch of medical study—histology—has been created by its means alone; while its contributions to morbid anatomy and physiology, or pathology, are indispensable to the student or physician who would excel, or even keep pace with the progress of others, in his profession. To such the following remarks will doubtless be interesting.

Histology is that science which treats of the minute or ultimate structure and composition of the different textures of organized bodies. It is derived from ἱστὸς, a tissue or web, and λογος, a discourse.

The attempts made by the early microscopic observers to determine ultimate structure, were in general of little value, partly on account of the imperfections in the instruments employed, and partly from the mistakes they made in judging of the novel appearances presented to their view. This last cause of error still exists, and inexperienced observers may very readily be led astray. By such, a fibre of cotton upon the stage of the microscope, moving in obedience to the hygrometric influence of the breath or of a moist atmosphere, might be regarded as a living animal; or the influence of various reagents on pus, mucus, blood, or other matters, might lead to error. This last was the case with the celebrated Borelli, who was the first to apply the microscope to the examination of structure.

Borelli was born in 1608, and lectured as professor in the University of Pisa in 1656. In his day a general idea prevailed, that diseases were occasioned by animalculæ existing in the animal tissues and fluids. An examination of abnormal fluids with the microscope favored this idea, as the globules were immediately taken for living beings. Borelli described the pus globules as animalcules, and even says he has seen them delivering their eggs. It will be seen that this was a very natural mistake, when we remember that these globules contain several minute granules, which make their escape when the external envelope is broken or dissolved. In this way we often find the germs of truth in the curious speculations of the early microscopists.

Malpighi was the first to witness the most beautiful sight which the microscope can reveal,—the actual circulation of the blood, thereby demonstrating the reasoning of Harvey to be true. The first work he published, in 1661, comprises his microscopic observations relative to the structure of the lungs. Between this period and 1665, he published other tracts on the

minute anatomy of the kidneys, spleen, liver, membranes of the brain, &c., and several of the structures still retain his name. He also paid attention to the anatomy and transformations of insects, the development of the chick in the egg, and the structure of plants. It will be perceived from the last remark, that the intimate connexion between animal and vegetable physiology was even then acknowledged. This connexion has led to the establishment of the cell doctrine, or the theory of the development of all organized tissues from cells.

Lewenhoeck has sometimes been called the father of micrography. He was born at Delft, in Holland, in 1663, and appears to have received a rather indifferent early education. He first brought himself into notice by the skill with which he ground glasses for microscopes and spectacles, and for improvements in those instruments; thus affording a good model for microscopic observers: first attending to the optical and mechanical construction of the instrument he was to employ. In 1690 he discovered and demonstrated the capillary blood-vessels. He opposed the chemical doctrines which then reigned in medicine, which attributed disease to fermentation in the blood. He objected; that if fermentation existed, air bubbles would be seen in the vessels, which was not the case. He showed that the blood-globules were of different sizes and forms in various tribes of animals; examined the brain and nerves, the muscles, the crystalline lens, the milk, and numerous other textures and fluids; and made the interesting discovery of the spermatozoa, which he conceived to be of different sexes. There can be no doubt that he made numerous errors, but the whole subject being new, his errors were excusable; and his contributions to science are still of the highest interest.

Swammerdam, Lyonet, and Ellis, after this period, greatly extended our knowledge of the lower tribes of animals; while

Lieberkuhn, Fontana, and Hewson labored successfully in the department of histology.

To Lieberkuhn we owe the first good account of the anatomy of the villi, and of the minute tubular glands of the small intestine, which still bear his name. As a minute injector he has never been surpassed.

Fontana examined the brain, nerves, muscles, and several other textures, with great care, and his observations were extremely accurate.

Hewson is celebrated for his accurate observations on the blood and lymph corpuscles. He first demonstrated that the blood-globules were flat, with a central nucleus, and not round, as had been previously supposed.

Nearly all the celebrated men alluded to, made use of the simple microscope. At this period the compound microscope was very defective. It was more of a toy than a scientific instrument.

From an ignorance of many phenomena connected with the microscope which are now well understood, many errors resulted. Optical illusions were mistaken for natural appearances, as was the case with Monro. In his discoveries respecting the brain and nerves, he describes them as being formed of convoluted fibres, and in his examination of other textures he saw the same fibres and always mistook them for nerves. The fact was, that he made his observations while the direct rays of the sun were transmitted through the substance under examination, and the optical phenomena which were produced led to the mistake. He afterwards found them on the surface of metals, and then frankly acknowledged his error.

Another source of early errors was the treatment to which their preparations were subjected before examination. It is now well known that animal tissue should be examined while fresh and transparent. What result is it possible to draw from

the observations of those who boil, roast, macerate, putrefy, triturate, and otherwise injure the delicate tissues? Most of the tissues contain albumen, which, so treated, gives origin to globules, and flakes of different forms; a circumstance which has led several anatomists to conceive the basis of animal structures to be globular. Several late observers have also made this mistake.

Messrs. Todd and Bowman, the learned authors of "The Physiological Anatomy and Physiology of Man," present the following sensible remarks respecting this subject,—"To make microscopical observation really beneficial to physiological science, it should be done by those who possess two requisites: an *eye*, which practice has rendered familiar with genuine appearances as contrasted with those produced by the various aberrations to which the rays of light are liable in their passage through highly refracting media, and which can quickly distinguish the fallacious from the real form; and a *mind*, capable of detecting sources of fallacy, and of understanding the changes which manipulation, chemical reagents, and other disturbing causes may produce in the arrangement of the elementary parts of various textures. To these we will add another requisite, not more important for microscopical than for other inquiries; namely, a freedom from preconceived views or notions of particular forms of structure, and an absence of bias in favor of certain theories, or strained analogies. The history of science affords but too many instances of the baneful influence of the *idola specûs* upon the ablest minds; and it seems reasonable to expect that such creatures of the fancy would be especially prone to pervert both the bodily and the mental vision, in a kind of observation which is subject to so many causes of error, as that conducted by the aid of the microscope."

The invention of the achromatic object-glasses for micro-

scopes formed the beginning of a new epoch in histological pursuits. Since that period, the confusion and opposition which formerly existed among observers have diminished, and at present only those differences remain which are incident to the pursuit of any other branch of scientific study.

In our own times, the Germans seem to have taken the lead in histological observations; and the reputation of the well-known names of Ehrenberg, Müller, Schwann, Schulz, Wagner, Weber, and Valentin, principally depends on the discoveries they have made by means of the microscope.

In England, the names of Carpenter, Todd, Bowman, Owen, Cooper, Busk, Quekett, Bowerbank, and others, are connected with microscopic research.

In our own country, a spirit of emulation seems excited which promises great advantage. Professor Bailey of West Point, and our townsmen, Drs. Leidy and Goddard, may be mentioned among others who have contributed to this result. The recent lectures of Dr. Goadby (late minute dissector to the Royal College of Surgeons, England), on microscopic science have done much to increase a desire on the part of medical students and others to become practically acquainted with this subject. His lectures to the students of the Philadelphia College of Medicine, and at other places, were well attended; as likewise were his private classes. Of his valuable suggestions I have frequently availed myself.

The advantage of a practical acquaintance with the microscope by medical men may be easily seen, and is readily acknowledged. Dr. Bennet, of Edinburgh, to whom I am indebted for much of the histological part of this introduction, says—"I have lately had many opportunities of satisfying myself that death may be occasioned by structural changes in the brain which are altogether imperceptible to ordinary vision and which have escaped the careful scrutiny of the first morbid

anatomists in this city. Again, who would have imagined that porrigo favosa, mentagra, aphtha, and other diseases, consist of cryptogamous plants growing on the skin or mucous membranes? Surely facts like these hold out a strong inducement to the histologist who prosecutes pathological inquiries." In another place he relates the following circumstance, which tends to illustrate the same point: "A gentleman who had an abscess in the arm, observed one morning his urine to be turbid, and to deposit a considerable sediment. The practitioner who attended him thought it looked like purulent matter, but before finally forming his diagnosis, he asked me to examine it with the microscope. I did so; but instead of finding pus corpuseles, discovered a large quantity of irregularly formed granules, which I recognised to be fibrinous. I immediately suggested that the abscess was on the point of resolution, and I afterwards learned, that from that time it rapidly disappeared. The fact that fibrin exuded into the tissues, and, subsequently absorbed, passes off by the kidneys, was determined by the microscopic observations of Schönlein and Zimmerman in Germany."

Many other instances might be adduced, were it necessary, to show the importance of the microscope in diagnosis and in practical medicine. It is not too much to hazard the assertion, that in a few years the practitioner will find it as essential in finding out the nature of disease, and the state of the system, as the most valuable articles of the materia medica are useful in medical treatment. The following example will illustrate the delicacy as well as utility of this mode of investigation. A few evenings since, while entertaining a friend with some microscopic views, he expressed a wish to see the red globules of the blood; so, pricking the tip of his finger with a lancet, a drop was extracted, which, after covering with thin glass, was placed upon the stage of the microscope. Observing the glo-

bules, with a greater tendency than usual, to run together into rows, like piles of coin, I remarked to him that his blood assumed an inflammatory or a feverish appearance. He replied, that he had been for about thirty-eight hours without sleep, having sat up with a sick friend the night before, and having some gastric irritation in addition, he had felt feverish all the evening. Observations on pus, mucus, the urine, and the various forms of malignant tumors, &c., all exhibit the value of this instrument to medical science.

In medico-legal researches the microscope has already proved a valuable auxiliary. It has several times been employed to ascertain the true nature of spots suspected to be blood-stains, &c.; and in cases where human life was suspended upon its decision.

In 1837, M. Ollivier was directed to ascertain whether any human hair was attached to the blade of a hatchet seized in the house of a person suspected of murder, and if this were the case, to determine the color of the hair. With the microscope, M. Ollivier ascertained that the filaments attached to the hatchet were the hairs of an animal, and not of a human being; and this was afterwards fully proved.

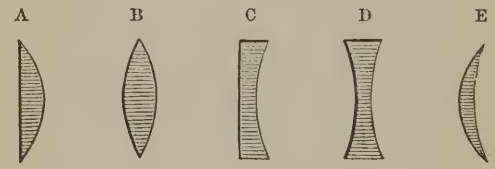
CHAPTER II.

THE MICROSCOPE.

THOSE who have examined a common magnifying glass (or lens) know that it is necessary to hold it exactly at a certain distance from the object viewed through it, in order that such object may be seen with distinctness. The point at which the object must be placed is called the *focus* of the lens, and the distance from the middle of the lens to the focus is the *focal length*, or focal distance of the lens.

The cut represents sections of the different forms of lenses. A, is a plano-convex lens. B, double convex. C, plano-concave. D, double concave. E, a meniscus.

Fig. 1.



The effect of the convex lens or of the meniscus is to cause the rays of light which pass from any object through them, to converge towards a point or focus; and the eye receiving those

rays after passing through the lens, sees the object apparently magnified. This principle is the basis upon which all microscopes are constructed.

The concave lens produces a precisely contrary effect to that described above. The rays of light diverge on passing through it, and the object appears diminished in size.

SIMPLE MICROSCOPES.

A plano or double convex lens, especially when mounted, or arranged with conveniences for viewing objects, is called a simple microscope.

The magnifying power of a simple microscope is in proportion to the shortness of its focal length. Thus, a lens of 2 inches focal distance, magnifies 5 diameters (or the superficies 25 times)—of 1 inch focus, 10 diameters—$\frac{3}{4}$ths of an inch, 15 diameters—$\frac{1}{2}$ inch, 20 diameters—$\frac{1}{4}$ inch, 40 diameters—$\frac{1}{8}$th inch, 80 diameters—$\frac{1}{10}$th inch, 100 diameters.

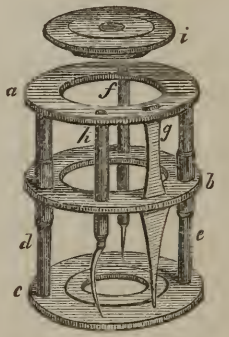
This table of magnifying powers is not invariably correct, owing to the difference of vision in different individuals, but it is sufficient for all practical purposes.

Simple microscopes are mounted in a variety of ways, according to the purposes for which they are intended. Some are made to turn upon a hinge into a case, so as to carry in the pocket; and others are fixed on a handle, with a pin or small pair of forceps in the focus, on which a small object, as an insect, &c., may be placed.

The cut, Fig. 2, exhibits the arrangement of Dr. Withering's Botanical Microscope, which is valuable from its simplicity. It consists of three brass plates, *a*, *b*, *c*, parallel with each other,

to the upper and lower of which the stout wires, *d*, *e*, are rivetted. The middle plate, *b*, which forms the stage for carrying the objects, is made to slide up and down on these wires. The upper plate, *a*, carries the lenses, *i*, and the lower one, *c*, sometimes carries a mirror, for reflecting the light of a candle or of the sky through any transparent object which may be placed on the stage. Into the stage a dissecting knife, *h*, a pointed

Fig. 2.

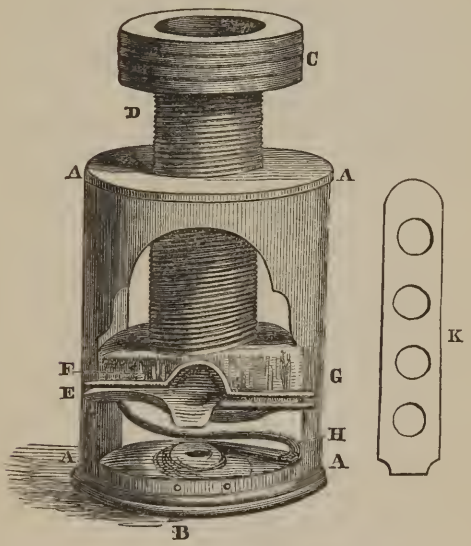


instrument, *f*, and a pair of forceps, *g*, are made to fit, and can be readily taken out for use by sliding the stage down nearly to the mirror.

A very useful kind of simple microscope was that invented by Mr. Wilson; an early form of which is represented by Fig. 3. The body, A, A, A, A, which was made either of ivory, brass, or silver, was cylindrical, and about two inches in length, and one inch in diameter. Into the lower end, B, the magnifiers are screwed, and into the upper end screws a piece of tube, D, carrying at the end, C, a convex glass, and on its outside a male screw. Three thin plates of brass, E, are made to slide

easily in the inside of the body to form the stage. One of these plates, F, is bent semicircularly in the middle, for the reception of a tube of glass, for viewing the circulation of the

Fig. 3.

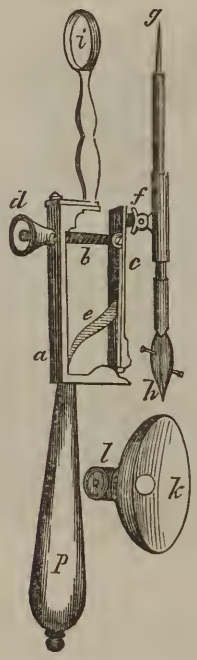


blood in small fish, while the other two are flat, and between these last the object-sliders, K, are introduced. Between the stage and the end of the body, B, is a bent spring of wire, H, to keep the stage and object steadily against the screw-tube. The object is adjusted to the focus by turning the screw D. This instrument was held in the hand in such a position that the light of a lamp or candle might pass directly into the con-

densing glass. It was afterwards improved by the addition of a handle placed at right angles to its body.

The best form of the simple microscope for viewing opaque

Fig. 4.

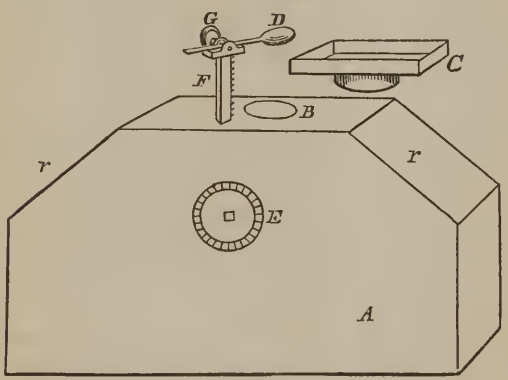


objects, is that represented by Fig. 4 : *a* is a flat piece of brass attached to the handle, *p*; it supports the lens-holder, *i*, and through it passes the screw, *b*, which is connected to the back-plate, *c*; a spring, *e*, keeps the plates, *a*, *c*, apart, and the nut,

d, adjusts the lens to the focus of the object, either on *g* or *h*. But the chief merit in its construction consists in a concave speculum or mirror of silver, *k*, highly polished, to the centre of which, at *l*, the magnifying glass is adapted. This is screwed into the ring *i*, and so held that a bright light, as from a candle or white cloud, is received upon the speculum (called a Lieberkuhn, from the name of its inventor). The light so received is concentrated upon the object, which is brightly illuminated; and is adjusted to the focus of the lens by turning the nut *d*.

For minute dissection of animal or other tissues, which is generally performed under water, as hereafter described, the

Fig. 5.



microscope of Mr. Slack, with the improvements of Dr. H. Goadby, F.L.S., is the most efficient. The following is a description of the instrument employed by the latter gentleman in his microscopic researches; and with which he has made a

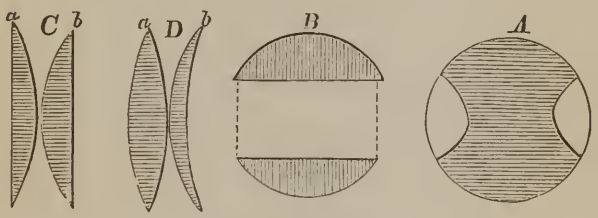
great number of beautiful preparations in minute anatomy, entomology, &e. It consists of a box or case, which is represented by A, Fig. 5. The upper surfaces *r*, *r*, are sloped off to form arm-rests. The front of the ease (which is not seen in the cut) is furnished with a flap or door, which has hinges at the bottom and a lock at the top; so that the various parts of the instrument may be packed up inside.

In the top of the box is a round hole, B, into which fits the short piece of tube atttached to the tin box, C, which is designed to hold the water in which the dissection is made. The ring, D, is the lens-holder, which is adjusted to the proper focus by means of the milled head, E, which moves the rack, F, up and down, working inside the box A. The lens-holder has also a horizontal motion, by means of the rack and pinion, G. Another horizontal motion is produced by a swivel joint attached to F. Inside the box is a mirror, directly under the hole B, so that the light can be directed upwards through any transparent object at B.

When moderate power only is needed, a simple microscope is the best instrument which can be used; and for the purpose of making minute dissections it is also the most convenient; but when a very high magnifying power is needed, combined with distinctness of observation, a single (or simple) microscope is found to be imperfect: although very small lenses have been made, which magnify exceedingly—quite enough for all useful purposes. Good lenses, of a high magnifying power, may be made by drawing out a very narrow strip of glass in the flame of a spirit lamp, and upon the end of the thread thus formed, running a small globule by means of the flame, which may be detached from its thread and placed between two thin plates of metal in which a small hole has been drilled.

Optical Improvements in the Simple Microscope.—There are imperfections of vision attending the use of all common lenses; arising either from the shape of the lens, or from the nature of light itself when passing through a refracting medium. These imperfections are termed respectively, spherical and chromatic aberrations. To lessen or destroy these aberrations various plans have been proposed, with various success. Mr. Coddington proposed a lens in the form of a sphere, cut away round the centre, as at A, Fig. 6. This is an excellent form for a hand lens, but is not often to be procured in this country, opticians preferring to dispose of the Stanhope lens, seen at B,

Fig. 6.

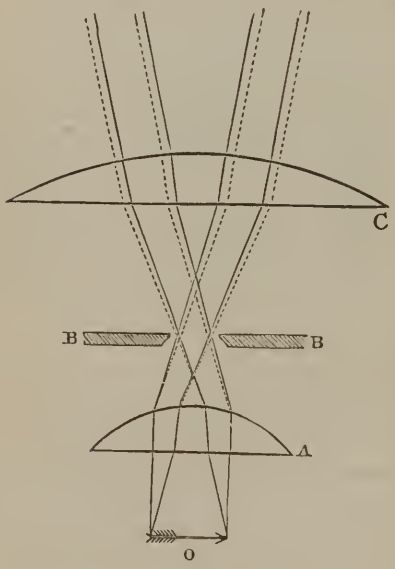


which is more easily made than the Coddington lens, but is inferior to it. C and D are doublets proposed by Sir John Herschell; the first of which consists of two plano-convex lenses, *a*, *b*, whose focal lengths are as 2·3 to 1, with their convex sides together; the least convex next the eye, D, consists of a double convex lens, *a*, next the eye, and a meniscus, *b*. When these lenses are used for forming images the lenses marked *a* should be next the object.

Other forms of doublets have been proposed, but by far the

best arrangement of this kind is *Dr. Wollaston's Doublet*, which consists of two plano-convex lenses, whose focal lengths are as 1 to 3; the plane sides of each, and the smallest lens, placed towards the object. The lenses are set in separate cells so as to adjust their proper distance apart, which is best done by experimenting on their performance, although their distance is about the difference of their focal lengths. Between them is a diaphragm or stop, generally placed immediately behind the

Fig. 7.



anterior lens. The stop was not employed by Dr. Wollaston, as his lenses were of such high power that they nearly touched

each other; yet it is, nevertheless, found to be essential to a good doublet.

A, C, Fig. 7, represent the lenses of the doublet, and B is the diaphragm or stop. The manner in which the light is refracted by this instrument, is shown by the lines proceeding from each end of the object, O. The dotted lines represent the blue or most refrangible rays of the spectrum; the others are the red rays. Those rays which pass through the centre of the lens, A, are caused to pass through the hole in the diaphragm over to the margin of B, and those nearest the margin of A, pass next the centre of B; and so become nearly corrected: the imperfection of one being made to counteract that of the other.

An improvement was made upon this by Mr. Holland, and is called *Holland's Triplet.* It consists of a doublet in place of the first lens, A, in the last figure; retaining the stop between it and the lens C. This form is the highest stage of perfection which the simple microscope has ever yet attained. The great objection to its use, however, is, that it must be brought into such close proximity to the object, that it is impossible to cover such object except with the thinnest mica, which is objectionable on account of its liability to be scratched.

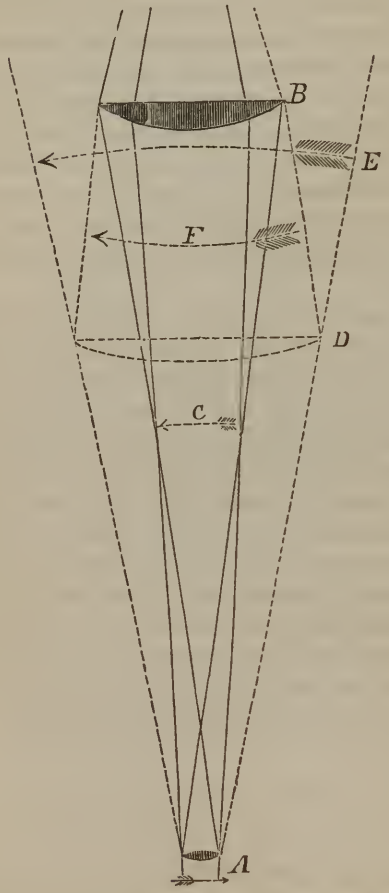
Before dismissing the subject of single microscopes, it may be well to remark, that for a low magnifying power, a double convex lens is the best to use; but for medium or high powers, a plano-convex lens, with the convex side towards the object; or one of the doublets just described; is preferable.

THE COMPOUND MICROSCOPE

Consists essentially of two convex lenses; an object-glass and an eye-glass; as represented in Fig. 8.

A is the object-glass, which forms a magnified image of the object at C, which is further enlarged by the eye-glass B. An

Fig. 8.



additional lens, D, is usually added; for the purpose of en-

larging the field of view. It is called the field-lens. An inspection of the dotted lines in the figure will show that many of the rays pass beyond the reach of the eye-glass, B: an image from these rays is represented at E. These rays are intercepted by the field-glass D, and form an image at F, which is viewed by the eye-glass.

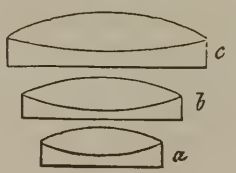
In looking through a common microscope of this kind, the observer will probably see rings of color round the edge of the field of view, and also similar colors around the edges of the object he is viewing. These defects arise from the decomposition of common white light; and are called chromatic aberration or dispersion. The colors round the field of view are produced by the defects of the eye-piece; and those round the object, by the object glass. Again: if the object be looked at through the instrument as before, its outline or edges will be observed, not sharp and distinct, but thick and confused. This is caused by the rays not being collected into a perfect point as they were on the object itself. This defect is called spherical aberration. When an instrument has neither its chromatic nor spherical aberration removed, it is said to be uncorrected.

To conceal these defects there is generally a small hole or stop behind the object glass. This is injurious to correct vision, as it prevents a large portion of light from entering the eye, and makes the objects appear dark, so that their true structure cannot be made out. When this is the case, the instrument is said to want angular aperture. The stop referred to, however, is essential even to the moderate performance of a common instrument.

To obviate all these difficulties, improvements have been made both in the object-glasses and the eye-pieces. Wollaston's Doublet has been found capable, when used as an object-glass with the Huygenian eye-piece (hereafter described), of trans-

mitting a large pencil of light with great distinctness, having an angular aperture of from 35° to 50°. Mr. Holland's Triplet, used in the same way, is capable of transmitting a pencil of 65° with distinctness and correctness of definition. The achromatic object-glasses, as first proposed by Mr. Lister, have however superseded all other attempts to improve the compound microscope, and have raised it from the condition of a mere toy to be the most valuable instrument of scientific research. They are made of plano-concave flint, and double-convex crown glass lenses, cemented together. Three compound lenses form the object-glass for a microscope, as represented by Fig. 9, *a*, *b*, *c*. In object-glasses of a high power,

Fig. 9.

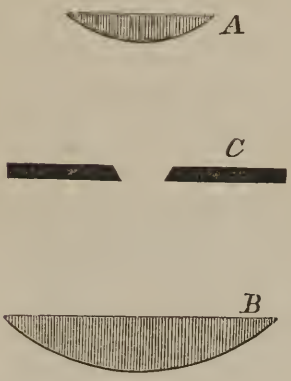


the anterior compound lens, *a*, has sometimes an adjustment to render it suitable for objects either uncovered or covered with glass of various thickness. The object-glass, thus made, is not quite achromatic, being rather over-corrected as to color, but is finally corrected by using the Huygenian eye-piece, shown in Fig. 10.

This eye-piece consists of two plano-convex lenses A, B, with their plane sides next the eye. In the focus of A is the diaphragm or stop, C. The proportions of the focal lengths of these lenses should be as 3 to 1, and their distance apart, one-half the sum of their focal distances. Thus if B be three

inches focus, A should be one inch, and their distance apart two inches.

Fig. 10.



Sometimes, when a very flat field of view is required, as in the use of a micrometer eye-piece, the convex sides of the lenses face each other. It is recommended that for this kind of eye-piece the lenses should be nearly of the same focal length, and at a distance equal to two-thirds the focal length of either.

A good compound microscope should be furnished with many mechanical conveniences, in addition to the optical part just described. It should be capable of being steady in any position from vertical to horizontal—have coarse and fine adjustments for focus—have a large and firm stage, with ledge, clips, &c.; and with traversing motions, so as to follow an object quickly, or readily bring it into the field of view,—and should have a concave and plane mirror, of two inches diameter, with a universal joint, and capable of being brought nearer or farther from the stage, as likewise of reflecting a side-light.

A variety of forms have been given to the mechanism of the compound microscope, many of which are very good, while others are exceedingly objectionable. Suffice it to say respecting them, that steadiness, or freedom from vibration, and particularly freedom from any vibrations which are not equally communicated to the object under examination and to the lenses by which it is viewed, is a point of the utmost consequence. A microscope body containing the lenses, screwed by its lower extremity to a horizontal arm, is the worst form conceivable.

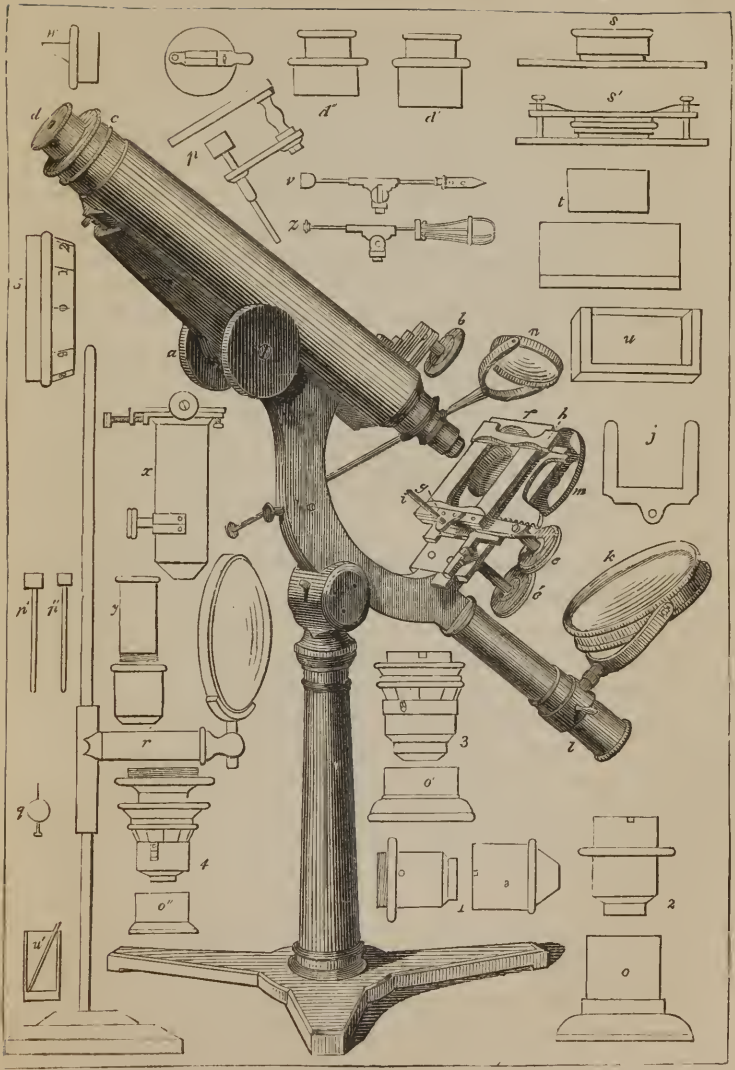
The compound microscope consists of three parts—the optical part, containing the object-glasses and eye-piece; the stage for holding the object; and the illuminating apparatus, which is either a mirror below the stage for transparent objects, or an illuminating lens for those which are opaque. Whatever form may be given to the mechanical arrangement, the parts alluded to are found in all, and the principles of their management are the same.

The most celebrated artists in the manufacture of these instruments are Powell and Lealand; Ross; and Smith and Beck, of London. A microscope from the latter firm is represented in the opposite cut.

The body slides by a rack and pinion, moved by the milled head, *a*, on a strong dovetailed bar; and has also a slow motion for delicate adjustment of focus, given by the milled head *b*. It is furnished with a sliding tube, *c*, for varying its length; and with three sliding Huygenian eye-pieces, *d*, *d'*, *d''*, of successive powers.

The erecting glasses, *y*, are to be screwed, when employed, into the other end of the sliding tube. They rectify the image, which is inverted when seen in the usual way. Their chief advantage is in microscopic dissection.

The stage has two steady rackwork motions, at right angles


d
c
a
b
x
y
r
q
l
3
4
2
1
o
o'
o''
s
s'
t
u
j
k
v
z
p
p'
p''
u'
d'
d''

to each other and to the axis of the body, given by the milled-heads, *c*, *c'*; it has also a sliding and revolving plane, *f*, with a ledge, *g*, for resting object-slips upon, and a sliding-piece, *h*, with springs for clamping them. An upright rod, *i*, is fixed on this plane for mounting the forceps, *v*, or for the spring-holder, *j*, when a glass trough, *u*, is used. A profile of the glass trough, with its diagonal plate of glass for conforming an object, is seen at *u'*. At *z*, is a three-pronged forceps.

A large double mirror, *k*, concave on one side and plane on the other, is supported by the cylindrical bar, *l*, and may be moved upon it vertically and sideways.

A movable diaphragm, *m*, is fixed under the stage for varying the quantity and direction of the light when transparent objects are viewed. The illuminating lens, *n*, is used for condensing light upon opaque objects; and a silver side-reflector is for the same purpose. The bull's-eye lens, for increasing the illumination, is seen at *r*.

An achromatic condenser, *x*, slides into the place of the diaphragm, to give the utmost refinement to the illumination of transparent objects.

The live-box, *s*, is for observing living objects between two glass plates; and a second live-box, *s'*, with screw collar, for objects in water. The screw is for regulating the depth of water, and the degree of pressure employed.

A plate of glass, *t*, with a ledge, has a separate piece of thin glass to lie upon it, for viewing animalcules, &c., in water.

The camera lucida, *w*, has its prism fixed on a short tube with a slight side motion for adjustment, and fits on each eye-piece when its cap is removed.

The three Lieberkuhns, *o*, *o'*, *o''*, adapted to the object-glasses 2, 3, and 4, are applied by sliding them in front of each respectively. When one of these is used, the diaphragm is to be removed, and the dovetailed piece, *p*, may be slid in its

place, with one of the three dark wells or stops, p, p', p'', which will make a dark background. If the objects are mounted on circular discs, g, the well will not be needed.

The object-glasses comprise four powers. No. 3 and No. 4 have the tube of their front lens movable, for adjusting their performance with objects either uncovered or covered with thin glass. The graduated screw collar, by which the adjustment is made, is seen at 5.

The high price of these instruments must necessarily put them out of the reach of those whose means are limited, and our opticians seldom import them, except to order. Of late, however, a praiseworthy effort has been made to simplify the construction of the mechanical parts, so as to bring the price within the control of the generality of medical men and other students of nature. Mr. J. B. Dancer, Manchester, England, furnishes a very complete microscope, with two object-glasses and the necessary apparatus, for £10. Messrs. Powell and Lealand have also fitted up an instrument with a stand of cast-iron, whose cost, exclusive of the object-glasses, is £9. Other manufacturers are also pursuing the same course.

From the cause above referred to, the majority of microscopes used in this country are of French or German manufacture. Chevalier and Oberhauser have furnished some excellent instruments; but the mechanism not allowing the mirror to turn aside from the axis of the instrument, so as to give a side light, is a serious objection to them, although the optical part is often very little inferior to the English.

Dr. Bennet, of Edinburg, highly recommends Oberhauser's instruments to medical men. He advises the employment of the No. 3 and No. 7 object-glasses, answering to the ¼ inch and 1 inch lens of the London opticians.

Hitherto, the fashion in this country in regard to microscopes, has led to the almost universal employment of high powers, to the neglect of the others, so that it is exceedingly difficult to

procure an achromatic object-glass with shallow magnifiers, notwithstanding the decided advantage to be derived from their use.

The microscopes of M. Nachet, and M. Brunner, of Paris, have been highly recommended. Those of the former which I have seen, are about on a par with the instruments made by Oberhauser, with the advantage of a larger stage.

Mr. C. A. Spencer, of Canastota, New York, has succeeded in manufacturing object-glasses, which are said to have an angle of aperture even greater than the best English achromatics. With them he succeeded in resolving the fine markings on the Navicula Spencerii, since adopted as one of the most difficult test objects.

A communication from Dr. J. L. Smith, to Silliman's Journal, describes the results of an examination of three microscopes by different makers. From this it would seem that for high powers, the object-glasses of Ross are the best, Spencer's rank next, while Nachet's are not much inferior.

The best defining object-glass I have yet seen is one I have made by combining two of Oberhauser's with one of Chevalier's, so as to make a triple objective. With this the sets of markings on the Navicula Angulata are beautifully seen by oblique light.

Such are the practical difficulties attending the production of such delicate instruments, that there must be a very great difference in the glasses even of the same maker, so that before purchasing an instrument, it is always best to examine it by means of some of the test objects hereafter described.

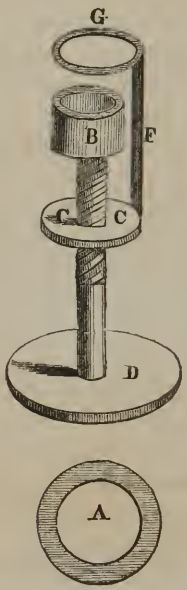
REFLECTING MICROSCOPES,

In which the image was formed by a concave mirror instead of a lens, are not now so much used as formerly. They are generally complicated in structure, and are surpassed and therefore superseded by the achromatic microscope.

The following is a simple reflecting microscope, invented by Mr. S. Gray, and may be of some interest from its singularity.

A, Fig. 11, represents a brass ring, one-thirtieth of an inch thick, whose inner diameter is about two-fifths of an inch. Having dissolved a globule of quicksilver in one part nitric acid and ten parts water, he rubbed with it the inner surface

Fig. 11.



of the ring, which became silvered; having wiped it dry, he put a drop of quicksilver within it, which, when pressed with the finger, adhered to the ring, and formed a convex speculum. When the ring was taken up carefully, and laid on the margin of the cylinder, B, the mercury sank down, and formed a concave reflecting speculum. The cylinder, B, is supported by a pillar, which is attached to the foot, D. The stage, G, is for holding the object, and is adjusted to the focus by the screw at C.

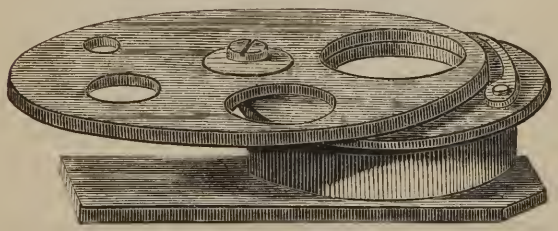
CHAPTER III.

ADJUNCTS TO THE MICROSCOPE.

In addition to the mirror, object-glasses, eye-glasses, and the parts constituting the stand of a microscope, several accessory instruments are needed by those who would devote attention to microscopic researches. The most necessary or useful of these we proceed to describe.

The Diaphragm, for cutting off extraneous light when

Fig. 12.



viewing minute transparent objects, consists of a plate of brass perforated with several holes of different sizes. This revolves on a pivot, so as to bring each hole in succession under the object-glass. It is adapted under the stage of the instrument, and is so essential in practice that few microscopes are made without it.

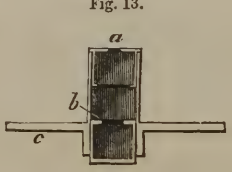
The Condenser.—This is an arrangement under the stage

for condensing the light upon the object. The best instruments employ an arrangement of achromatic glasses, similar to the object-glasses, but its value is scarcely equal to its cost. The Wollaston Condenser is a short tube, in which a plano-convex lens of three-fourths of an inch focal length, with its flat side towards the object, is made to slide up and down. Dr. Wollaston employed a long tube with a stop between the lens and the mirror, but Dr. Goring found it better to have the stop between the lens and the object, and a little out of the axis of the lens.

A substitute for the achromatic condenser is found in Mr. Varley's dark chamber. This is sometimes preferable to the Wollaston Condenser, as the light is not decomposed by passing through a lens.

c, Fig. 13, is a plate of brass adapted to the stage, in which is a short tube having a diaphragm or stop, *a*, whose aperture

Fig. 13.



is equal to what can be viewed by the microscope, and no larger. Below is a sliding tube, *b*, with an aperture rather larger than that at *a*. This last can be moved up and down until the light at *a* is of the greatest intensity. The aperture at *a* is always in proportion to the object-glass employed.

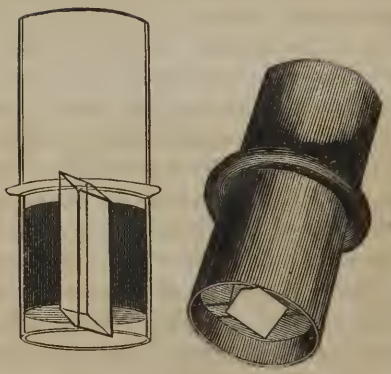
Condensers for oblique illumination.—As the lines on some test objects require an illumination at a considerable angle from the axis of the microscope, various plans have been suggested for the purpose. The most simple mode is to turn aside the

concave mirror from the axis of the instrument, but in this way the illumination is confined to one side of the object while the other side is in shadow. M. Nachet has contrived an oblique prism which can be revolved so as to throw oblique light successively on all parts of the object. Mr. Wenham's illuminator consists of a truncated parabolic mirror (somewhat the shape of the half of an egg-shell with about half an inch of the apex cut off) fastened beneath the stage plate. At the bottom of this mirror is a circular stop of the size of the opening at the other end. This carries a dark well up nearly to the stage plate. When this illuminator is used the light is thrown up by means of the plane mirror, and by reflexion from the parabola is made to pass behind and around the dark well. Direct light is prevented by the circular disc or stop. This is a most admirable contrivance. The objects appear brilliantly illuminated on a dark ground. The illuminator usually has a meniscus at the small end to correct the aberration of the slip of glass which carries the object.

Nobert's illuminator, like the last, throws an oblique light all round an object, and of course there is no shadow. It consists simply of a thick plano-convex lens, in the centre of the convex surface of which a deep concavity is made. The plane side is turned towards the object, and it is placed in a manner similar to the Wollaston Condenser. The concavity in the lens is equivalent to a dark spot on the convex surface, so that a hollow cone of light is obtained, in the apex of which the object is placed. It is necessary to have lenses of different sizes for object-glasses of different focal lengths.

Polarizing Apparatus (Fig. 14), for viewing objects by polarized light. It consists usually of two prisms of calcareous spar, in proper tubes; one below the stage, and the other in the eye-piece. Sometimes a thin piece of tourmaline is used in place of the prism in the eye-piece.

Fig. 14.

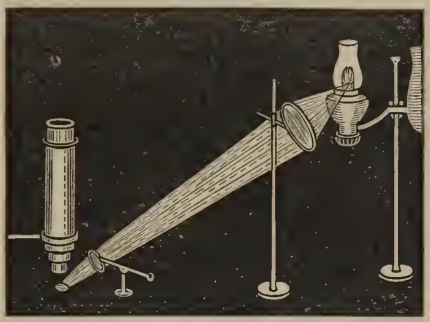


Erector.—This is sometimes supplied with the best instruments. It consists of a pair of lenses acting like the erecting eye-piece of the telescope. It is applied to the draw tube at the end of the eye-piece towards the object-glass. It is only used when it is desired to dissect with the compound microscope, as, without it, the position of the object appears reversed.

Condensing Lens and Lamp.—The Wollaston Condenser, &c., is designed to concentrate the light which comes from the mirror, directly upon the object; but the condensing lens and lamp is used either for opaque objects, or to condense the light upon the mirror itself. Two such lenses, as in the figure, are generally used. Dr Goadby informed me, that after many experiments he has found a bull's-eye lens, of three inches focal length, the most efficient for the larger lens; and after several trials with different sorts of lenses I am disposed to agree with him. Fig. 15 illustrates one mode of using the condensers upon opaque objects. A, is the bull's-eye lens,

which turns upon its axis, and slides up and down a stout wire affixed to a steady foot. B, is the smaller lens, whose handle

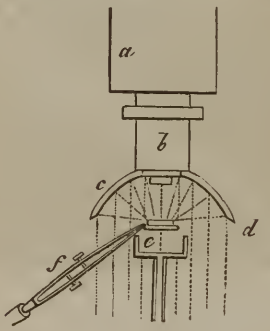
Fig. 15.



slides through a socket, working on a hinge-joint. Sometimes a lens of this kind is affixed to the stage of the microscope, when it can be used in combination with the bull's-eye lens, or alone. C, is the object upon which the light is concentrated. D, the lamp. To condense the light on the mirror, the lens, A, alone is used. The lamp is of the kind called a fountain lamp, and slides up and down a stem, on which it can be fixed at any height by a screw. A shade should always be used with the lamp, in order to screen the eye as much as possible from any light save that which proceeds through the instrument. As it is a matter of much consequence to our observations that we should have a steady intense light, it is not immaterial what kind of oil, &c., we employ. After many trials and disappointments, I am convinced that pure sperm oil is the pleasantest, cheapest, and best. Camphene, burning-fluid, and gas give out a very intense light, but there is a tremulous motion in the flame, which is somewhat unpleasant.

Lieberkuhn, or Silver Cup.—This is a most useful instrument for viewing opaque objects. It is attached to the object-glass in the manner represented by Fig. 16, where *a* is the lower end of the body of the microscope, *b* the object-glass,

Fig. 16.



to which the Lieberkuhn, *c*, is attached. The rays of light reflected from the mirror, are brought into a focus upon an object, *d*, mounted in the usual way upon glass, or held in the forceps, *f*. When the object is transparent, or is too small to fill up the entire field of view, the dark well or stop, *e*, is used. This is generally fixed into the centre of the stage, a little below the upper surface. Sometimes, instead of a Lieberkuhn, a side-reflector is used, and from the greater obliquity of its reflection, is of great advantage in exhibiting delicate structures.

It has hitherto been considered impracticable to use very high powers with opaque objects, but the Athenæum informs us that "at one of Lord Rosse's recent scientific soirees, Mr. Brooke showed his new method of viewing opaque objects under the highest powers of the microscope (the $\frac{1}{8}$th and $\frac{1}{12}$th

inch object-glasses). This is performed by two reflections. The rays from a lamp, rendered parallel by a condensing lens, are received on an elliptic reflector, the end of which is cut off a little beyond the focus, as in Wenham's illuminator for oblique light; the rays of light converging from this surface are reflected down on the object by a plain mirror attached to the object-glass, and on a level with the outer surface. By these means the structure of the scale of the podura, and the different characters of the inner and outer surface, are rendered distinctly visible." I have not had an opportunity of testing this plan, but have little doubt of its success.

Camera Lucida.—By which drawings are made from the microscope. This is generally formed by placing a small prism of glass, inclined at the proper angle, in front of the eye-piece. In Fig. 17, *a*, represents the camera, formed of highly-polished

Fig. 17.



steel, smaller than the pupil of the eye, inclined at an angle of 45°, and fixed to a clip, *b*, which embraces the eye-piece.

Frog-plate; Fig. 18; on which frogs or fish are tied to examine the circulation of blood in their vessels. The frog, &c., must first be enclosed in a bag, and fastened on the plate by the holes in either side of it. Then thread is tied to about

four of its toes, and the web is spread out over the large hole by fastening the ends of the thread through the small holes in the plate.

Fig. 18.



The Stage Micrometer consists of a slip of glass, pearl, &c., having a line finely divided into parts of an inch, &c. To obtain with this the power of a compound microscope, compare the divisions seen with one eye through the instrument, with a rule held ten inches off, and looked at with the other eye. Suppose, for instance, the micrometer be divided into $\frac{1}{100}$ths of an inch, and one of these divisions covers an inch of the rule seen with the other eye, the magnifying power of the instrument is 100 diameters. If it should cover five inches, it is magnified 500 diameters. By sketching the object by means of the camera, and then putting in its place a stage micrometer, and marking the divisions over the sketch, they can again be subdivided, and so the measure of an object be accurately taken.

Animalculæ Cage is a round cell with a glass bottom and top, for confining a drop of water with animalculæ.

Fig. 19.



Fig. 20.



Watch-Glasses and *Fishing Tubes*, are useful adjuncts. The latter, Fig. 19, are glass tubes of various sizes, by which when

one end is closed with the finger a quantity of water, &c., may be lifted from a phial, as seen at Fig. 20, and put in a watch-glass. By their aid, too, with a little practice, an animalcula may be caught in a phial, when it is visible to the naked eye. With the finger on one end of the tube, approach the other end to the place where the animal is, then suddenly lifting off the finger, the current will carry it into the tube.

A Compressorium, for applying pressure to an object; a *trough* for chara and polypi; a *phial-holder,* &c.; will also be found useful.

CHAPTER IV.

HOW TO USE THE MICROSCOPE.

MANY persons imagine that the value of a microscope is in proportion to the apparent size of an object seen through it. This, however, is a mistake. The greater the magnifying power of an instrument, all other things being equal, the greater is the difficulty of finding a minute object on the stage, and of adjusting the focus. The light, too, transmitted from the mirror, becomes less intense, and the view less satisfactory with the use of high powers. For the majority of objects, a low or medium power is always preferable, on account of the greater extent of the field of view. The test objects, however, and the minute structure of any delicate tissue, &c., require very considerable amplification in order to exhibit them satisfactorily. When this is the case, the increase of power should be given by the employment of an object-glass of shorter focal length, in preference to the use of a more powerful eye-piece.

Sir David Brewster gives the following rules for microscopic observations.

1. The eye should be protected from all extraneous light, and should not receive any of the light which proceeds from the illuminating centre, excepting what is transmitted through or reflected from the object.—This rule will illustrate the use of the diaphragm under the stage of the microscope.

2. Delicate observations should not be made when the fluid which lubricates the cornea of the eye is in a viscid state.

3. The best position for microscopic observations is when the observer is lying horizontally on his back. This arises from the perfect stability of the head, and from the equality of the lubricating film of fluid which covers the cornea. The worst of all positions is that in which we look downwards vertically. The most common and easy position is generally with the instrument inclined at an angle of 45 degrees.

4. If we stand straight up and look horizontally, parallel markings or lines will be seen most perfectly when their direction is vertical; viz., the direction in which the lubricating fluid descends over the cornea.

5. Every part of the object should be excluded, except that which is under immediate observation.

6. The light which illuminates the object should have a very small diameter. In the day-time it should be a single hole in the window shutter of a darkened room, and at night an aperture placed before an Argand lamp.

7. In all cases, particularly when high powers are used, the natural diameter of the illuminating light should be diminished, and its intensity increased, by optical contrivances.

The following remarks by Mr. James Smith, copied from the Microscopic Journal, vol. i., are recommended to the consideration of all who are in the habit of using microscopes. "Much of the beauty of the objects seen depends upon the management of the light that is thrown upon or behind them; which can only be fully mastered by practice. It may be remarked, however, as a general rule, that in viewing those which are transparent, the plane mirror is most suitable for bright daylight; the concave for a lamp or candle, which should have the bull's-eye lens, when that is used, so close to it that the rays may fall nearly parallel on the mirror. If the bull's-eye lens is not used, the illuminating body should not be more than five or six inches from the mirror. The latter

is seldom required to be more than three inches from the object, the details of which are usually best shown when the rays from the mirror fall upon it before crossing, and the centre should (especially by lamp-light) be in the axis of the microscope. For obscure objects, seen by transmitted light, and for outline, a full central illumination is commonly best; but for seeing delicate lines, like those on the scales of insects, it should be made to fall obliquely, and in a direction at right angles to the lines to be viewed.

"The diaphragm is often of great use in modifying the light, and stopping such rays as would confuse the image (especially with low or moderate powers), but many cases occur when the effects desired are best produced by admitting the whole from the mirror.

"If an achromatic condenser is employed instead of the diaphragm, its axis should correspond with that of the body; and its glasses, when adjusted to their right place, should show the image of the source of artificial light, or, by day, that of a cloud or window bar in the field of the microscope, while the object to be viewed is in focus.

"The most pleasing light for objects in general, is that reflected from a white cloud on a sunny day; but an Argand's lamp or wax candle with the bull's-eye lens is a good substitute.

"A large proportion of opaque objects are seen perfectly well (especially by daylight) with the side-reflector, and the dark box as a background; and for showing irregularities of surface, this lateral light is sometimes the best; but the more vertical illumination of the Lieberkuhn is usually preferable, the light thrown up to it from the mirror below being, with good management, susceptible of much command and variety."

The management of the light with opaque objects must depend in a great degree upon their size, and the manner in

which they are mounted. If the object is small, and so mounted as not to intercept much of the light from the mirror, the mode illustrated by Fig. 16 is the best; in other cases, that shown in Fig. 15 is preferable.

The transmission of light obliquely, as near as possible at right angles to the axis of vision, which is recommended in the foregoing extract, for viewing delicate lines, has a very fine effect, the field of view being dark, while the objects are brilliantly illuminated. The lines on the most difficult test objects, as some species of Naviculæ, &c., are to be seen in this manner of illumination, even when otherwise invisible. For producing this oblique illumination in the best manner, several ingenious pieces of mechanism have been invented; see page 42.

Next to the proper illumination of the object, the adjustment of the focus is the most important thing to be attended to. With a low power, the coarse adjustment is usually sufficient if the workmanship be good; but with a high power it becomes necessary to resort to the more delicate arrangement of the fine adjustment. Great care must be taken, however, lest the glass on which the object is mounted be broken, or the object-glass injured, by too sudden or too close a contact.

CHAPTER V.

ON MOUNTING AND PRESERVING OBJECTS FOR EXAMINATION.

If a low power is used, and the object be one not necessary to be preserved, it can be well seen if placed in the forceps or on a slip of glass, but if it be desired to keep it for future examination, some method of preserving it from decay, dust, &c., must be resorted to; and the method will vary according to the nature of the object.

TRANSPARENT OBJECTS.

Transparent objects are mounted on slips of glass, the size of which, as adopted by the Microscopic Society of London, is 3 inches by 1 inch, or 3 inches by $1\frac{1}{2}$ inches. The French opticians, however, prepare many of their slides $2\frac{1}{4}$ inches by $\frac{5}{8}$ths of an inch, and this size is most frequently imported into the United States; indeed, a larger size is unsuitable for many of the French instruments, although to be preferred on other accounts.

There are three methods of mounting transparent objects. 1st, in the dry way—in which the object is simply placed upon the slip of glass, and covered with a thin glass cover, cemented by its edges to the under piece, with sealing-wax varnish, &c.

2dly. In some preservative fluid.

3dly. In Canada balsam.

The glass slides should be clear, free from veins and bubbles, of uniform length and breadth, and should have their edges ground smooth by rubbing them on a flat cast-iron plate with emery and water.

Sections of teeth and bone, and of some kinds of wood, hairs of animals, scales of butterflies, test objects from the infusoria, &c., are best mounted dry; but all very delicate animal and vegetable tissues, to exhibit their structure clearly, should not be mounted in the dry way, nor in Canada balsam, but in some preservative fluid.

Preserving Fluids.—A very considerable number have been recommended by different observers. A mixture of salt and water was used by Dr. Cook for this purpose; there is an objection to it, however, owing to the development of a confervoid vegetable.

Mr. J. T. Cooper, some years since, made some experiments with a view to determine the best fluid for preserving vegetable colored tissues, such as some of the smaller fungi, and found that salt and water, 5 grains to the ounce of water, to which acetic acid had been added, answered very well. A few drops of creosote or of camphor will prevent the growth of confervæ.

One part alcohol to 5 of distilled water, will preserve even very delicate colors. There is, however, the same objection to the use of this fluid as to the salt and water. When this is used, asphaltum cement may be employed for securing the thin glass cover to the cell.

Pure glycerine is prepared by the London opticians as a preservative fluid, and is used in the proportion of 1 part to 2 of water. Its oily nature, however, often causes much difficulty in cementing the thin glass cover upon it.

A weak solution of chromic acid,—one part to twenty of

water—is a good preserving fluid. It is also recommended for hardening soft tissues, as the brain, liver, &c., for future dissection. Dr. Vanarsdale, in his introduction to the American edition of Hassall's Microscopic Anatomy, speaks highly of it in this respect.

One part of naphtha to seven or eight of water is said to be employed by Messrs. Hett, Topping, and others, in their injected preparations.

One part alum to sixteen of water preserves animal structures for some time, though bone is injuriously affected by it.

A saturated solution of sulphate of zinc is said to preserve animal tissues well, with the advantage of hardening cerebral substance, but it dissolves albumen so as to cloud the liquid. Mr. Straus Durkhein says it destroys all parts of caterpillars, save the teguments, while the perfect insects are well preserved in it.

Tulk and Henfrey state that 26 drops of creosote in a wine-glassful of distilled water, preserves well, but renders the preparations brown.

Dr. Goadby has devoted much attention to this subject, and has succeeded in supplying to the microscopist a ready, cheap, and effectual means for mounting animal structures with the greatest possible ease and security. Dr. G. received a gold medal from the Society of Arts for his invention. He has kindly furnished me with the following description of his different preserving fluids.

"A 1. Bay salt (coarse sea-salt), 4 ounces,
Alum, 2 ounces,
Corrosive sublimate, 2 grains,
Boiling water, 1 quart.

"A 2. Bay salt, 4 ounces,
Alum, 2 ounces,
Corrosive sublimate, 4 grains,
Boiling water, 2 quarts.

"The A 1 fluid is too strong for most purposes, and is only to be employed where great astringency is required to give form and support to delicate structures.

"The A 2 fluid may be very extensively used, and is best adapted for permanent preparations; but neither of these fluids should be used in the preservation of animals possessing any carbonate of lime (all the Mollusca), as the alum becomes decomposed, and the sulphate of lime is formed and precipitated, and the animal spoiled. For such use the

"*B fluid, specific gravity* 1·100.

Bay salt, 8 ounces,
Corrosive sublimate, 2 grains,
Water, 1 quart.

"Marine animals require a stronger fluid of this kind, viz., specific gravity 1·148, which is made by adding more salt (about 2 ounces) to the above.

"The corrosive sublimate is used to prevent vegetation growing in the fluid, and no greater quantity should be used than 2 grains per quart of fluid; but, as it coagulates albumen, it must be left out when ova are to be preserved, or when it is desired to maintain the transpareney of certain tissues."

Mounting in Fluid.—The most minute structures, such as the vessels of plants, and the muscular and other tissues of animals, requiring in all cases high powers for their proper exhibition, must of necessity be preserved in very thin cells with a small amount of fluid.

On a slip of glass, 3 inches by 1, cleaned by a solution of caustic potash to remove all grease, lay a drop of the fluid; put the object in this and spread it out with the point of a needle, &c. Select a thin and flat glass cover, clear it likewise from grease, &c., touch its edges with cement, and drop it gently over the object. Press it lightly, to exclude the excess

of fluid, which can be removed by strips of blotting-paper. Then cement the edges of the cover to the bottom glass. Care must be taken to exclude all air-bubbles from between the glasses. Objects mounted thus do not keep long, and it is best to make a thicker cell. This may be made by painting a round or square ring on the slip with some sort of cement which will not be acted upon by the fluid employed.—White lead worked with 1 part linseed oil and 3 of spirits of turpentine is well adapted for this purpose.—In this ring, the fluid and object are placed and the cover put on.

Pieces are also cut off the ends of glass tubes and cemented on the slips with marine glue, so as to form very neat cells. A square piece of glass, with a hole drilled in it, cemented on the slip, forms an excellent cell. Such cells, ready prepared, are imported and kept by McAllister & Co., Chestnut Street above Second, Philadelphia; together with slips, thin glass for covers, mounted preparations, a good variety of instruments themselves, and other things interesting or useful to the microscopist.

Holes may be drilled in square pieces of glass, when a number of them are cemented together with marine glue, by means of a copper tube (or drill) on a lathe, which is used with fine sand or emery and water. This form of cell, as well as the built-up cell, as it is called (which is a glass box, the edges of whose sides are cemented with marine glue), was first contrived by Dr. Goadby.

Pieces of gutta-percha tubes, cemented on to the slips by heat, may sometimes be used for cells, and answer a good purpose. Excellent cells may be made by using narrow slips of glass for the sides, cementing them with marine glue. They are oblong or square, and are well suited for the larger class of objects.

The thin glass cell, which is made by cutting or drilling a

hole in a square piece of thin glass, such as is used for covers, and cementing it to the slide, will be found of use in mounting delicate structures. For the thicker class of objects the tube cells, or those built up with strips of glass, are most suitable.

CEMENTS.

Japanners' Gold-size, or Severe Dryer, is a mixture of boiled linseed oil, dry red lead, litharge, copperas, gum animi, and turpentine. The first and last ingredients are its principal constituents. Mr. Williams, Artists' Furnishing Store, Sixth Street above Market, Philadelphia, has it for sale.

Sealing-wax Varnish consists of small pieces of sealing-wax dissolved in alcohol.

Asphaltum, dissolved in turpentine, has this advantage, that spirit may be employed as the preserving fluid if desired.

Marine Glue is a mixture of shell-lac, caoutchouc, and naphtha. It is melted by heat. Caustic potash will remove its traces from glass. Tulk and Henfrey give the following recipe for its preparation: Dissolve 1 pound of caoutchouc in 4 gallons of coal naphtha; 1 pint of this solution is mixed with 2 pounds of shell-lac;—it is a most useful preparation for building up glass cells, &c. Powdered gum arabic, made into a mucilage with distilled vinegar, is said to be a very powerful cement. If greater consistence is required a little calomel may be added.

Gum Mastich and Caoutchouc, dissolved in chloroform, is an excellent cement, and has the advantage of remaining fluid at ordinary temperatures, while the rapid evaporation of the chloroform enables the slide to be quickly prepared. This was suggested by Dr. Goddard. The caoutchouc should first be dissolved in the chloroform, by the application of gentle heat, to the consistence of thick mucilage, gum mastich should then be added until it becomes sufficiently liquefied.

A solution of Canada balsam in ether or turpentine, evaporated to such a consistence that it can be laid on with a camel's-hair pencil, may be used like the last described, as a substitute for marine glue.

Lampblack and white hard varnish, when laid on immediately, is a good cement. Sealing-wax and white lead have also been recommended.

For the thin glass covers, a mixture of the gum mastich cement, above described, with asphaltum dissolved in turpentine, will be found very suitable. Dr. Goadby recommends for the same purpose, a mixture of equal parts of gold size and asphaltum dissolved in camphene. This should be applied in layers, which should be isolated from each other by coating with a solution of gum arabic or of marine glue dissolved in white-wood naphtha. The object of this isolation is to prevent the cement from penetrating between the glasses. Some very valuable preparations have been ruined from this cause.

MOUNTING IN BALSAM.

Before objects are mounted in Canada balsam they should be perfectly clear and free from moisture. They are commonly soaked in turpentine, especially opaque objects, as it renders them more transparent. Grease may be removed by sulphuric ether.

Very thin and transparent objects become indistinct in balsam; they should be made dark. Vegetable matters may be charred between two plates of glass over a lamp. Other structures which cannot be charred, may be dyed by soaking in a decoction of fustic or logwood, or a weak tincture of iodine.

The balsam should be warmed on the slide to expel the air.

When objects of a cellular nature have to be mounted, if they are such as heat will not much injure, they may be boiled in the balsam; otherwise numbers of air-bubbles will be left in the cells, and the true structure cannot then be made out satisfactorily. The extra degree of heat will expand the air and cause it to escape, and the balsam will take its place.

Some object of a tubular nature, such as the tracheæ of insects, are better seen if air be contained in the tubes; they will then exhibit the spiral fibre in their interior; but a tracheal tube filled with balsam does not show the fibre at all, the balsam having made all the parts transparent. Small insects, such as fleas, and the parasites of animals, when not overheated, show the ramifications of the trachea, but those which have been soaked long in turpentine, or have had the air expelled by heat, do not exhibit the spiral markings except under polarized light.

When air is to be got rid of, the heat must be high; otherwise, the use of turpentine must be avoided, the heat of the balsam kept low, and the mounting accomplished quickly.

The best way to heat the balsam on the slide is to place the slide on a small table made of iron or tin, to which a spirit-lamp is applied, as first suggested by Dr. Goadby; yet with careful management a spirit-lamp will do alone.

Some persons keep their balsam in a tin vessel that can be warmed so as to melt it. A drop of the fluid can then be taken out and put on the object upon the slide. This plan is attended with little or no risk of air-bubbles. The cover should be warmed on its under surface before it is laid on the balsam, and if necessary, a small amount of heat applied to the under side of the slide, to make the balsam flow more rapidly.

When animal structures, such as parts of insects, or injections, have to be mounted, the heating of the balsam must be

carefully managed, and the balsam itself be very fluid to commence with. It should be sufficiently warmed to expel all air-bubbles, and, when nearly cold, the object should be placed in it and covered in the usual way. By pursuing this plan (for which, with many other suggestions, I am indebted to Mr. Quekett's admirable work on the Microscope), I have succeeded in making some excellent preparations at the expense of but little time and trouble. Some operators, after covering the object with balsam, if it is one that heat is likely to injure, as an injected specimen, &c., leave the slide for a day or two, to allow the air-bubbles to escape before putting on the glass cover. But by careful management, the plan above referred to will serve the purpose more readily.

If the heat applied to the slide be great, the object will be sure to curl up, and bubbles will appear in all parts. It will most likely be rendered useless, as no manipulation, however carefully applied, will restore an overheated specimen of animal structure to its former beauty.

After the slide has been prepared as above, the superfluous balsam may be removed with the point of a knife previously warmed in the flame of a spirit-lamp, &c. The remaining traces of balsam may be removed by an old linen rag dipped in turpentine or sulphuric ether.

MOUNTING IN THE DRY WAY.

For objects which require a high magnifying power, they may be placed on a slide and covered with thin glass, whose edges may be touched with cement. Objects which do not require an object-glass of short focus, may be placed between two slips of glass whose edges have been levelled so as to form a groove, which may be filled up with cement or sealing-wax.

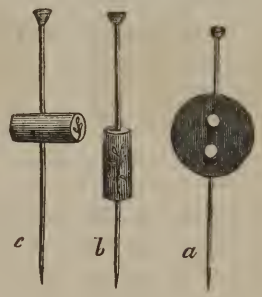
If the object be too thick to allow the cover to approach the

slide, the intervening space may be filled with paper, pasteboard, &c., in which a hole has been cut. Such intervening substance is very useful to prevent pressure upon the object. If desirable, the name of the specimen, &c., may be written on this paper, especially if the cover and slide be equal in size.

MOUNTING OPAQUE OBJECTS.

These must necessarily be viewed by light reflected in some manner from their surface. Some transparent objects, however, may be viewed as opaque ones by using the dark well or stop, *e*, Fig. 16. When mounted with this design they may be placed on the slip of glass with a little gum-water, and surrounded with a rim of card, paper, &c., sufficiently thick to form a proper cell, which may be covered with thin glass. Sometimes opaque objects are fixed on a round piece of black paper stuck upon a slide.

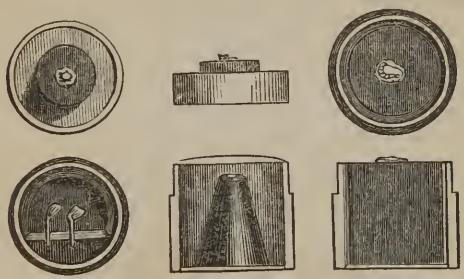
Fig. 21.



a, Fig. 21, represents a disc of leather, felt, or other suitable material, about three-eighths or half an inch in diameter, with a pin passing through it. The side for holding the object is to

be blackened; the other side is covered with white paper, on which the name is written. *b* represents another plan, for very minute objects; the pin is encased with blackened wax or cement, or passes lengthwise through a small cork cylinder Another method is seen at *c*, which consists of a small cylinder of cork or felt with a pin passing transversely. These must be blackened with common lacquer (shell-lac dissolved in alcohol) and lampblack, holding them over a candle to dry. Sometimes these cylinders are made of ivory, with the inside turned hollow like a small box; the pin runs through them as at *c*, and supports the object. The ivory is dyed black, and the inner surface made as sombre as possible. Mr. Quekett recommends to place the objects on pieces of cork glued to the

Fig. 22.



bottom, side, or cover, of small pill-boxes, as seen in Fig. 22. Opaque objects should always be viewed with a black ground, and the darker the object, the more sombre must be the mounting. White is, of all colors, the worst which can be employed, unless the object is totally black.

MOUNTING CRYSTALS FOR POLARIZED LIGHT.

These must be so enclosed that the air is completely excluded, otherwise a change will take place, and the objects be spoiled. When it can conveniently be done, it is well to mount them in Canada balsam. Sir David Brewster recommends mixing cold-drawn castor oil with the Canada balsam. In this case the edges of the thin glass cover should be cemented, as the castor oil prevents the balsam from becoming hard.

Each preparation should be properly labelled, either with a writing diamond on the glass slide, or on the paper cover of the slide; and it may save trouble if this be invariably performed as soon as mounted.

CHAPTER VI.

ON PROCURING OBJECTS FOR THE MICROSCOPE.

THE topic suggested by the title of this chapter is almost endless; for the microscopist may claim contributions from every department of natural science. The animal, vegetable, and mineral kingdoms, all offer him interesting objects of investigation. We shall content ourselves with noticing some of the most important or attractive in each department.

INORGANIC.

Agate.—This form of silica is often found imperfectly crystallized, and thin plates, prepared by the lapidary's wheel, $\frac{1}{50}$th of an inch thick, exhibit a rich motley coloring when viewed by polarized light.

Carbonate of Lime.—Small spherules of this substance are sometimes found in the urinary deposits of the horse. They are often composed of concentric layers; at other times the fibres are radial. Illuminated by polarized light under a power of 100 diameters, they are splendid objects.

Crystallization of Salts.—Independently of the beautiful forms assumed by different salts during their crystallization, a great variety of forms may be obtained by mixing small quantities of the different solutions in a little weak gelatine, starch, mucus, &c. To procure specimens, put a drop or two of water,

solution of gelatine, &c., upon a slide, put into it a drop of some strong solution of salts, as Epsom salts, hydrochlorate of ammonia, tartaric acid, &c. Hold the slide over the spirit-lamp until evaporation is perceived, when it should be removed and placed under the microscope. If the evaporation is too rapid, the crystals will not be well formed. They may be mounted dry, or in balsam. A power of 30 diameters is generally sufficient. Crystals of salts form interesting and splendid objects under polarized light.

Ice.—A plan for observing the crystallization of water is as follows. Mix some water with a little charcoal, chalk, &c., in such a manner that a number of fine particles may be mechanically suspended in it; then take a glass slide, place it on a cold night in an exposed situation, as outside of a window-sill; pour upon it as much water as it will support without running over the edge, and let it remain all night. The next morning, if the weather has been sufficiently cold and the atmosphere dry, neither water nor ice will be seen on the slide; but the particles of charcoal will be found arranged in the various forms which they assumed while the water crystallized. The slide may be carefully prepared with Canada balsam for preservation.

Crystals of Iron Pyrites and other substances; *Oolites;* and various sorts of *sand;* are interesting objects. The sand from Turkey sponge, and from the sea, often contains minute shells of various kinds, as the *foraminifera*, &c., corallines, and other zoophytes.

Sections of Granite, Limestone, &c., are also of considerable interest; but *sections of coal*, made very thin, so as to be viewed by transmitted light, develope clearly its vegetable origin, and are therefore of special importance.

Deut-Ioduret of Mercury.—The change of color in this salt is a beautiful object. If a little of it be placed in a watch-

glass, having another inverted over it, and then the lower one heated over the flame of a spirit-lamp, the salt will be sublimed. Placed on the stage of a microscope, with a power of 30 diameters adjusted to focus at the inner surface of the upper glass, minute crystals will be seen to form of a bright yellow color, which, as they cool, return to the original red.

VEGETABLE TISSUES.

Vegetable Tissues are prepared by tearing, making thin sections, maceration in water, dissection, or are examined in their natural state.

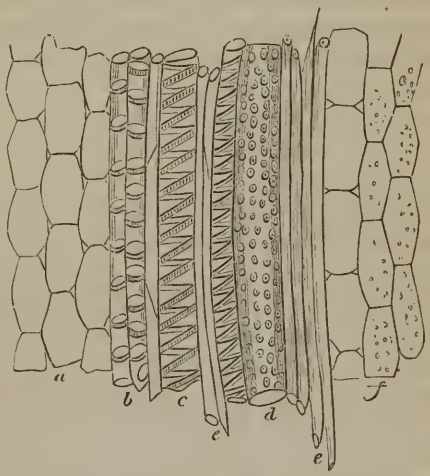
The spiral, dotted, and reticular vessels of plants require generally to be dissected out, which is to be done under a shallow magnifier. A single lens of one inch focus will answer very well for this purpose. Having procured a piece of asparagus, or the petiole of the garden rhubarb, &c., cut out a piece about an inch long, split it open with a sharp knife or scalpel, examine it under the magnifier, and separate with a needle-point any of the vessels you require from the surrounding cellular tissue. This process is facilitated by dropping a little water on the specimen. To prevent it moving, the specimen may be fixed with beeswax during the dissection. Vessels, ducts, and cellular tissue, when prepared, should be kept in spirits of wine until mounted.

Fig. 23 represents the tissues in a longitudinal section of Italian Reed; *a*, are cells of the pith; *b*, annular ducts; *c*, spiral duct; *d*, dotted duct; *e*, woody fibre; *f*, cells of the integument.

Cuticles.—The external covering of plants, or cuticle, consists of a thin membrane, adherent to the cellular tissue beneath it. Under the microscope it appears traversed by lines

in various directions, giving its surface a reticulated appearance. The form of these reticulations varies in different

Fig. 23.



plants: in some they are hexagonal, in others prismatic or irregular. Cuticles may be mounted dry or in fluid. The geranium, oleander, &c., afford good specimens. See Fig. 40.

The cuticle of the under side of the leaf of many plants, exhibits under the microscope dark spots among their reticulations. These are called stomata, and are the orifices by which a function analogous to respiration in animals is effected. They also serve for the exit of water from the plant by means of evaporation. Plants destitute of stomata, as the South American Cacti, &c., will remain in a hot and dry atmosphere without losing their moisture. The form, number, and arrangement of the stomata vary in different plants.

Cellular Tissue is the first and most generally developed

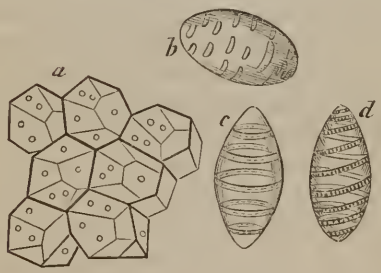
simple form of vegetable life. Its primary development may be seen by examining a small portion of yeast at intervals under the microscope. No plant is without cellular tissue, and many are destitute of any other kind of tissue, as the lichens, and some fresh-water algæ. A section of the pith of elder, pulp of peach, &c., will afford specimens.

The petals of flowers are mostly composed of cellular tissue; their brilliant colors arise from the fluid contained within the cellules. These form excellent microscopic objects, and when mounted in balsam are permanent. The pelargoniums and geraniums are among the most interesting.

The petal of the anagallis, or scarlet chickweed, is a beautiful object. The spiral vessels diverging from the base, and the singular little cellules which fringe the edge, are worthy of notice.

Cells differ in form according to the mode in which they are aggregated. *a*, Fig. 24, represents the dodecahedral and

Fig. 24.



dotted cells in the pith of elder. Cells are either surrounded by a simple membrane, or by thickened walls. The thickening of the wall takes place by a deposit of woody matter on the inside. Occasionally, portions of the cell-wall are left un-

covered by deposits, giving rise to porous cells (*b*, Fig. 24), or dotted cells (*a*, Fig. 24); at other times the thickening matter is in the form of a ring or spiral coil, constituting annular (*c*, Fig. 24) and spiral cells (*d*, Fig. 24).

Vascular Tissue, prepared by maceration and dissection, presents many interesting subjects. Spiral vessels, *c*, Fig. 23, consist of membranous tubes with conical extremities, internally furnished with one or more spiral fibres. As the vessels grow, the spiral fibre breaks into short pieces, forming rings. The vessels are then called annular, *b*, Fig. 23. If the pieces of fibre are still shorter, they are called dotted or reticulated vessels, *d*, Fig. 23. The root of the garden rhubarb, the stem of the hyacinth, the leek, &c., furnish examples.

A peculiar form of vessel is met with in the common carrot; it is obtained from a root in a layer between the yellow central portion and the red annulus.

Sections of Wood.—These are cut thin, so as to allow them to be viewed as transparent objects. Hard woods, containing gum, resin, &c., should be soaked in essential oil, alcohol, ether, &c., before mounting. By transverse slices, a variety of beautiful lace-like objects may be obtained, but little information is acquired from them of the real structure of the wood. For this purpose, if the tree is of the endogenous and branchless kind—which grow by additions to the interior—a vertical section is also necessary. If the tree be an exogen, two vertical sections will be required in addition to a transverse one. The exogens grow by annual layers exteriorly under the bark, and are branched. In these one of the vertical sections should be radial and the other tangental. The radial vertical section will show the number and size of the medullary rays; that is, the small portions of pith which proceed horizontally from the centre, enclosed in a sheath of woody fibres. The frequency and size of the medullary rays determine the number and

strength of the branches of the tree. This section also exhibits in coniferous trees (as the pine, &c.), the beautiful disc-like glands which adhere to the woody fibres. These are beautiful objects, and sometimes require a power of 200 or 300 diameters. The tangental vertical section is a slice across the medullary rays; it exhibits the form and arrangement of the cellular tissue within them. All the vertical sections show the form, size, and connexion of the woody fibres; spiral, reticulated, and dotted vessels, &c.; and are far more instructive than the transverse sections.

Charcoal.—Thin sections of charred wood are very interesting and instructive.

Fossil Woods.—Thin sections must be made by grinding on a lapidary's wheel. They should be polished.

Siliceous Cuticles, &c., from equisetum, straw, cane, &c., are prepared by heat in a covered crucible, or by boiling and digestion in nitric acid. The most favorable example for showing the form in which silica occurs in plants, is the husk of the oat or wheat. If a husk of oat be examined under the microscope, having been mounted in water or Canada balsam, a series of bright parallel columns, serrated on each side, may be observed among the cellular tissue: if another specimen be burned carefully between the glasses, and the ashes be mounted in balsam, the siliceous columns will still be seen. In the ashes of the husk of wheat, rows of concave discs may be observed, which are composed of some metallic oxide. In the ashes of the calyx and pollen of the mallow, organized lime may be detected. In the ashes of coal, a variety of vegetable structures, as cellular tissue, spiral vessels, &c., may be discovered. In these experiments it is necessary to render the ashes transparent by immersion in balsam.

Hairs, Down, &c., from leaves and stems, are generally opaque objects. In the plants which produce cotton, the hairs

are attached to and envelope the seeds. Hairs are composed of cellular tissue. Their functions are said to be either lymphatic or secreting. They offer great varieties in form, some being stellated, others forked or branching. The hairs of Virginian spiderwort (*Tradescandia Virginica*), the sting of the Nettle (*Urtica dioica*), and the radiating scale or hair in Elœagnus, the Oleaster, are interesting specimens.

Pollen may be mounted in Canada balsam; or, if rather transparent, in fluid; or dry. Sometimes the grains are interesting opaque objects. The common form of the pollen or farina of flowers is spherical, with a smooth, punctured, or spiny surface; but some are square, others cylindrical, oval with attenuated extremities, or triangular with convex sides. The pollen of the passion flower is very curious, and if immersed in very diluted sulphuric acid opens and disperses the grains. The pollen of *Datura stramonium*, or Jamestown weed, and others, when immersed in a few drops of weak acid placed upon a slide under the microscope, emits a tube of some length. The granular matter in the pollen may then be seen to pass along the tube until the pollen is emptied. The diameter of the pollen varies considerably in different plants; among the smallest are those of the Sensitive Plant.

Starch.—The granules of starch (not the ordinary impure starch of the laundress) obtained from different plants, are found, when examined under the microscope, to differ in size and form. Some are spherical, others elliptical, flask-shaped, polyhedral, &c. Hence this method of examination affords a ready means of detecting fraud in the substitution of one kind of grain for another. Starch granules, although so very minute, are composed of a fine and delicate membrane, enclosing a fine mealy powder. It may be compared in some respects to a common pea, in which the legumen is enclosed in a testa or skin. Starch granules are not soluble in cold water, nor is

iodine capable of acting on them while the membrane enclosing its contents remains whole. If the granules be triturated or immersed in hot water, the membrane will be ruptured, and iodine will then turn them blue. Starch is readily separated from wheat, potato, arrow-root, &c., by repeated washings in cold water. To obtain it from rice, the grains should be macerated for a few days, and to prevent the decomposition of the gluten, a little soda should be added to the macerating water. Under the microscope, the surface of starch-grains often appears corrugated, and each of them has one or two bright spots, called the hilum, which is supposed to be the part where the starch adheres to the cell. See Fig. 25. *a*, represents starch cells of the pea, showing grains of starch in the interior; *b*, separate grains of starch, with striæ and hilum; *c*, granules of wheat-starch; *d*, sago meal; *e*, rice-starch; *f*, potato-

Fig. 25.



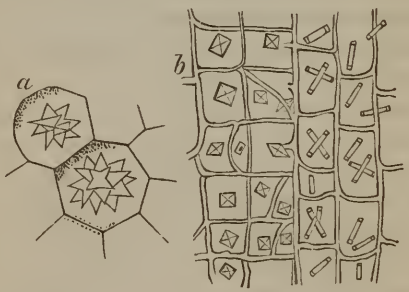
starch; *g*, isolated cells of rhubarb, containing starch-granules. Under polarized light they present the beautiful phenomenon of the black cross. They should be mounted dry, and protected from the pressure of the upper glass by a rim of thin paper.

Seeds are generally opaque objects, and present a great variety of beautiful and interesting forms.

Hard Tissues, the stones and shells of nuts, &c., are prepared like bone, &c., by cutting and grinding. Some require the lapidary's wheel.

Raphides, or crystals from the interior of plants. If the leaf or bulb of a common hyacinth be wounded, a discharge of fluid ensues; if this be received on a slide and submitted to the microscope, a number of minute acicular bodies will be observed floating in the liquid. They are called raphides. They are common in many plants. Fig. 26, *a*, represents cells of

Fig. 26.



the beet-root, containing conglomerate raphides; *b*, octohedral and prismatic crystals of oxalate of lime in the cells of an onion. By scraping hickory, or other bark, on to a slide, moistening it with the breath, and blowing off the woody particles; or by placing a part of the ashes of a burnt maple leaf, coat of an onion, &c., on a slide, such crystals may be seen. They may be mounted dry or in balsam.

Mosses are supposed to be destitute of woody fibre and vascular tissue. When a leaf is carefully examined, the septa

which divide the cells are sometimes found to take a spiral course. To observe this structure, soak the moss in water, to expand the cells.

It is essential, in collecting mosses, to preserve the theca or seed-vessel, for without it the genera cannot be determined; while this part, with the calyptra and operculum, are the most valuable for the microscope.

Algæ.—Are interesting objects. The green, mucous, slime-like matter in damp garden walks, and the hair-like weeds in ditches, are examples of fresh-water algæ. The sea-weeds of our coast are marine algæ, and are often found having zoophytes adhering to them; they are then splendid opaque objects. For mounting in balsam, the smaller kinds, of a bright scarlet color, are the most valuable.

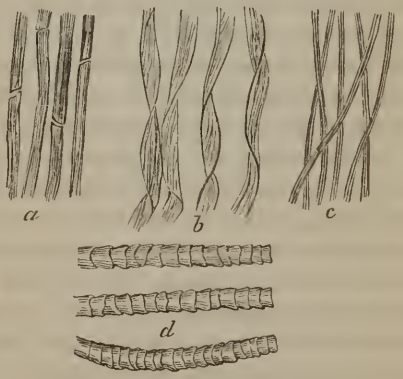
Ferns.—The genera are mainly distinguished by the position and arrangement of the organs of reproduction. These are mostly on the under side, or along the margin of the leaf or frond. They are best examined as opaque objects. They should be collected before they are quite ripe. The spores (seeds) are usually enclosed in brown capsules, each having an elastic ring about its equator, which when ripe bursts, and the spores are dispersed to a distance. Spores may be mounted either as transparent or opaque objects. The development of ferns may be observed by placing the spores in moistened flannel and keeping it at a warm temperature. At first a single cellule is produced, then a second, and so on. After this the first cellule divides into two, and then the others, by which a lateral increase takes place.

Lichens and *Fungi* afford interesting objects. The various kinds of mildew upon vegetable substances are familiar examples of minute fungi.

Organic Fabrics possess much interest in a commercial point of view, in addition to the curiosity arising from the

manner in which the threads or bundles of fibres are woven or interlaced. For this purpose they should be examined as opaque objects on a black ground, with a magnifying power of from 30 to 60 diameters. The fibres of cotton are readily distinguished under the microscope from those of linen, wool, &c. Cotton fibres are tubular, and are formed of pure cellular tissue. These tubes, from the thinness of their sides, often collapse and appear like flat ribbons or bands. The reason assigned for the preference given to linen (flax) over cotton for lint, for surgical purposes, is that the fibres of the former are solid cylinders of woody fibre, while the edges of the flattened bands of the latter are supposed to irritate the

Fig. 27.



wounds. Fig. 27 exhibits the different appearance of these fibres under the microscope; *a*, fibres of flax; *b*, cotton fibres; *c*, filaments of silk; *d*, wool of sheep.

Circulation in Vegetables.—The circulation in plants, termed *cyclosis*, is a revolution of the fluid contained in each cellule,

and is distinct from those surrounding it. It can be observed in all plants in which the circulating fluid contains particles of a different refractive power or intensity, and the cellules are of sufficient size and transparency. Hence all lactescent plants, or those having a milky juice, with the other conditions, exhibit this phenomenon. The following aquatic plants are generally transparent enough to show the circulation in every part of them:—*Nitella hyalina*, *Nitella translucens*, *Chara vulgaris*, and *Caulinia fragilis*. In the Frogbit (Hydrocharis), it is best seen in the scales surrounding the leaf-buds, with a power between 60 and 200 diameters.

The jointed hairs of the filament of the anther in *Trandescantia Virginica* (Spiderwort); the delicate hairs on the leaf-stalk of *Senecio vulgaris* (Groundsel); and a section of the leaf of *Vallisneria spiralis*, will show the circulation, especially when viewed with a high power.

For the following recapitulatory list of plants, which may be used in microscopic examinations, the author is indebted to Balfour's Class Book of Botany, Edinburg, 1852.

1. *Cells and Cellular Tissue.*—Sea-weeds; rice-paper; independent cells with nuclei, in yeast plant (Torula Cerevisiæ); cells with nuclei and nucleoli in ripe fruit of strawberry, in the onion bulb, and in ovules or very young seeds; cells united in a linear series in common mould, conferva, and many hairs; branching cells in many hairs, and in some moulds, as Botrytis; cells united in fours in pollen of Acacia, and in some species of sea-weeds; cells thickened by deposit of lignin, in the shell of the Cocoanut, and Attalea funifera or Piacaba palm, in the stone of the peach, cherry, and nut, in the seed of the Ivory palm and Date, in the gritty matter of the Pear; cells with siliceous covering in Diatomaceæ. Porous cells in Elder pith, in stem of common garden Balsam (Balsamina hortensis), in the outer covering of the seeds of Gourd and Almond,

in the wing of the seed of Lophospermum erubescens, and in Calempelis scaber. Spiral cells in leaves and stems of many orchids, as Onicidium and Pleurothallis ruscifolia, in garden Balsam, in the leaf of Sphagnum, the fructification of Liverworts, the winged seed of Sphenogyne speciosa. Annular cells in Opuntia. Filamentous cells in Mushrooms and Agarics. Hexagonal cells in pith of Elder. Stellate cells in Rush. Ciliated moving cells in Vaucheria, Fuci, and Chara. Professor F. Schulze states, that by means of nitric acid and phosphate of potash, the cells of plants, young or old, hard or soft, may be perfectly isolated for microscopic examination.

2. *Vessels and Vascular Tissue.*—Woody tissue in the stem of ordinary trees; the fibres may be separated by maceration from the inner bark of the Hemp-plant, Flax-plant, New Zealand Flax, Mallows, &c., Disc-bearing woody tissue in Scotch Fir, Weymouth Pine, Araucaria, Altingia excelsa, Cycas; Winter's bark tree, Illicium. Dotted vessels in stem of Willow, Sugar-cane, Pitcher-plant. Spiral vessels in Oncidium bicolor, Banana, and Plantain; most liliaceous plants (as Hyacinth, Lily, and Crinum), leaf of Geranium and Strawberry, Cabbage, Lettuce, Asparagus shoot; branched spirals in Long-leek and Anagallis. Annular vessels in Opuntia vulgaris, Leek, Equisetum1 Telmateia. Reticulated vessels in garden Balsam. Scalariform vessels in Tree Ferns, Diplazium seramporense, Asplenium pubescens, Osmunda. Lactiferous vessels in various species of Ficus, as the India-rubber fig (Ficus elastica), Gutta-percha plant (Isonandra Gutta), Euphorbias, Lettuce, Dandelion, Celandine, Goatsbeard.

3. *Contents of Cells.*—Starch-cells in Potato, angular starch-granules in Rice, compound starch-granules in Arrow-root, peculiar starch-grains in the milky juice of Euphorbia. Air-cells and lacunæ in the Rush, Sparganium ramosum, Limnocharis plumieri, and other aquatic plants. Cells with

raphides of oxalate of lime in Rhubarb root, cells with acicular crystals in Hyacinth, cells with octohedral and prismatic crystals in Onion and Squill. Oil-cells in rind of Orange and Lemon, in leaves of Hypericum, and of the Myrtle order. Chlorophyll cells in Mosses, Vallisneria, Chara; cells with coloring matter in leaf of Rottlera tinctoria, and in petals.

ANIMAL TISSUES, ETC.

INFUSORIA.—These minute animals, some of which are only the $\frac{1}{2500}$th part of an inch in diameter, are extremely numerous. Between 700 and 800 different species have been discovered and described. Dr. Ehrenberg, to whom we are indebted for much of our knowledge respecting the animalculæ, divides them into two classes, i. e., Polygastrica and Rotatoria. The first class is so named from their possessing a digestive apparatus composed of many globular vesicles, which perform the functions of stomachs. The Rotatoria are so called from their possessing rotary organs about their mouth. These are much more highly organized than the others. The Polygastrica increase by self-division, or by the growth of gemmules or buds upon their bodies; the Rotatoria are hermaphrodite, and oviparous. Many animalculæ are loricated; or protected by a shell, or shield, which is generally siliceous: others are destitute of such an appendage.

The following table exhibits the families or groups into which this interesting department of animal life has been divided by Ehrenberg. Those who wish further information respecting them are referred to his work "Die Infusionsthierchen," or to Pritchard's "History of Infusoria, Living and Fossil." Dr. Mantell's work on Animalcules contains also much valuable information.

CLASS I. POLYGASTRICA.

Anentera, or without true alimentary canal.

- Body destitute of appendages. (No foot-like processes.) *Gymnica.*
  - Form of body constant.
    - Self-division complete.
      - illoricated or shell-less, — Monadina.
      - loricated or shelled, — Cryptomonadina.
    - Self division incomplete, hence formed in clusters.
      - self-dividing on all sides (globular), — Volvocina.
      - self-dividing unilaterally (filiform).
        - illoricated, — Vibriona.
        - loricated, — Closterina.
  - Form of body variable.
    - illoricated, — Astasiaea.
    - loricated, — Dinobryina.
- Foot-like processes variable. *Pseudo-poda.*
  - illoricated, — Amoebaea.
  - loricated,
    - compound foot-like process from one aperture, — Arcellina.
    - simple foot-like process from one or from each aperture, — Bacillaria.
- Hairy *Epitricha.*
  - illoricated, — Cyclinida.
  - loricated, — Peridinaea.

Enterodela—with an alimentary canal.

- One receiving and discharging orifice only for nutrition. *Anopisthia.*
  - illoricated, — Vorticellina.
  - loricated, — Ophrydina.
- Two ditto orifices, one at each extremity. *Enantritena.*
  - illoricated, — Enchelia.
  - loricated, — Colepina.
- Orifices situated oblique. *Allotreta.*
  - illoricated,
    - mouth furnished with proboscis, tail absent, — Trachelina.
    - mouth anterior, tail present, — Ophryocercina.
  - loricated, — Aspidiscina.
- Orifices abdominal. *Cutotreta.*
  - illoricated,
    - locomotive organs cilii, — Kolpodea.
    - do. do. various, — Oxytrichina.
  - loricated, — Euplota.

CLASS II. ROTATORIA.

- With a simple continuous wreath of cilii. (*Monotrocha.*)
  - margin of cilii-wreath entire. *Holotrocha.*
    - illoricated, — Icthydina.
    - loricated, — Oecistina.
  - margin of cilii-wreath lobed or notched. *Schizotrocha.*
    - illoricated, — Megalotrochaea.
    - loricated, — Floscularia.
- With a compound or divided wreath of cilii. (*Sorotrocha.*)
  - with the cilii-wreath divided into several series. *Polytrocha.*
    - illoricated, — Hydatinea.
    - loricated, — Euchlanidota.
  - with the cilii-wreath divided into two series. *Zygotrocha.*
    - illoricated, — Philodinaea.
    - loricated, — Brachionaea.

In reference to obtaining infusoria, some persons imagine that if they procure a portion of fetid ditch-water, or take a few flowers, &c., and macerate them in water, they will be furnished in a few days with all the varieties they may desire; but this is not the case. Infusoria will of course be found, but they will be only of the most ordinary kinds. To obtain those of higher interest, some degree of skill is required. Many remarkable species have been taken in meadow-trenches in the slowly running water, after a summer shower, especially about the time that the first crop of hay was mown. Among healthy water-plants, the various kinds of Vorticellina (*Stentors* and *Vorticellæ*, or trumpet and bell-shaped infusoria), and Rotatoria (wheel-animalcules), may be sought for with success. The stems of aquatic plants have often the appearance, to the naked eye, of being encased with mouldiness, or *mucor*, which on being examined with the microscope, proves to be an extensive colony of arborescent animalcules. The dust-like stratum sometimes seen on the surface of ponds, and the shining film which sometimes covers water-plants, assuming various hues of red, brown, yellow, green, and blue, is caused by the presence of infusoria, some of which are very beautiful. Many species live in the clean fresh water of rivers, lakes, and springs; and the brine of the ocean, likewise, as well as the mould on the surface of the earth, has its microscopic inhabitants.

In order to procure animalculæ, provide yourself with a number of clean, wide-mouthed, glass phials, fitted with proper corks, not glass stoppers, so that the air may have access to them, at least to some extent. Have also a rod, or walking-cane, which may be prepared with a spring-hook and ferule for fastening a phial on its end, although a piece of twine is a good substitute. On reaching the pond, &c., carry the phial (attached to the rod) in an inverted position, and when at

proper depth, or in the neighborhood of water-plants, it should be turned quickly, when animalculæ, &c., will run into it. Water-fleas and Daphniæ should be frightened away by shaking the phial before turning. If in the phial, they go quickly to the bottom, and the upper water can be poured off. Examine the water with a pocket lens, and preserve the animalculæ.

The indications of the presence of infusoria are specks moving about in the water, or an apparent mouldiness around the stalks of the water-plants, &c., which may have been caught in the phial. If these appearances be not discerned by the magnifier, the water may be thrown away, and another place resorted to. A small portion only of vegetable matter should be preserved in the phial, as its decay may soon kill the animalcules.

Small newts and many larvæ should be preserved; the former especially, as they eat up the Daphniæ, Monoculi, &c., that destroy the Vorticellæ. In the branchiæ of young newts, too, and in their feet, the circulation of the blood is beautifully seen.

The phial should sometimes be laid horizontally on the bottom of the pond, and scrape the surface of the mud. This should be put in a large jar with water, and in a day or two the animalculæ will be on the surface of the mud, from which they can be removed with the fishing-tubes (see page 49), and placed under the microscope.

If the creatures are too minute to be seen easily with the naked eye, pour a little water from the vessel containing them into a watch glass, and place it on a piece of card-board, rendered half black and half white. The white ground will make the dark specimens apparent and vice versa. They can then be seen with the pocket lens, and taken out with the fishing-tubes.

In order to show the stomachs, cilia, &c., of animalculæ under the microscope, rub some pure sap-green or carmine on a palette or plate of glass, and add a few drops of water. If the glass be now held on one side, a portion of the coloring matter may be put into the water on the slide containing the animalculæ. If they be vorticellæ or rotiferæ, the particles of coloring matter will show the vibratile actions of the cilia, whilst other particles swallowed by the animals, will give a rich tint to the compartments of their alimentary canal.

Fossil Infusoria.—A great number of infusorial earths may be mounted in balsam (test objects dry, however) without washing, &c., but others must be repeatedly washed or digested in acid. For the skeletons or shields in carbonate of lime, consisting mostly of Polythalamia, or many-chambered shells, Professor Ehrenberg has directed to place a drop of water on the slide, and put into it as much scraped chalk as will cover the fine point of a knife, spreading it out, and leaving it to rest a few seconds; then withdraw the finest particles, which are suspended in the water, together with most of the water, and let the remainder become perfectly dry. Cover this with Canada balsam, and hold it over a lamp until it becomes slightly fluid without froth.

Siliceous Shields of Infusoria, such as those in guano, Richmond earth, &c., require to be well washed and boiled or digested in nitric or hydrochloric acid. After this, a small quantity of the sediment in which they are contained should be placed on a number of slides, and those containing the best specimens laid aside for mounting. In guano and Richmond earth are found most beautiful saucer-shaped shells, having hexagonal markings, which have received the name of Coscinodiscus, or sieve-like disc. They vary in size from $\frac{1}{100}$th to $\frac{1}{1000}$th of an inch in diameter.

The polishing slate of Bilin, which is found in strata fourteen

feet thick, consists almost entirely of the siliceous shells of Infusoria, so small that forty thousand millions are contained in a single cubic inch.

The eatable earth of Sweden and Lapland is likewise composed mostly of such shells. A layer of this earth occurs in the province of Luneberg, Saxony, which is twenty-eight feet thick. It contains a beautiful species of minute, oval, figured shell called the Campilodiscus.

Sponges.—These lowly-organized bodies are found both in salt and fresh water in all parts of the globe. Many of them are very minute, and may be examined without much preparation, but others require to be burned, or acted on by acid, to show the small masses of flint, called spicula, which form their rudimentary skeleton, as well as other masses of the same material, which enter largely into the framework of the young sponges or gemmules.

Corals are best examined by horizontal and vertical sections. If the animal matter only is required, the sections may be maccrated in hydrochloric acid, to which five or six times its bulk of water has been added.

Zoophytes.—Residents at the sea-side, or occasional visitors, when provided with a microscope, have frequent opportunities of examining some of these most elegant of animal forms. Scarcely a piece of sea-weed or a fragment of shell will be found, that does not afford a habitation for some member of this interesting family. The animals are generally found in clusters or compound; sometimes communicating at a common centre; at other times distinct and only connected by the solid matter of which their polypidoms are formed. Some few, as the common fresh-water polype, do not secrete any hard substance either around or within them.

Insects.—These afford the most numerous and beautiful

objects for examination, as there is scarcely a part of the body of an insect that does not exhibit some remarkable structure.

Antennæ.—The horns of insects not only vary in form in different genera, but in the male and female of the same species. They may be mounted as opaque, or in Canada balsam.

Eggs.—The eggs of insects are generally of an oval form, the outer covering being sufficiently rigid to resist ordinary external impressions; others are, however, soft and pliant. In some species they are globose, as in many Lepidoptera; or conical, as in the large white cabbage-butterfly; cylindrical, pear-shaped, barrel-shaped, &c. They are for the most part smooth; but many are very beautiful, ornamented with symmetrical ridges, canals, dots, &c., giving them, as Reaumer observed, the appearance of embossed buttons. Some are furnished with appendages for peculiar purposes. Thus the eggs of the dung-fly (*Scatophaga putris*) has two oblique props at one end, to prevent it sinking too deep in the matter upon which it is deposited, while those of the water-scorpion (*Nepa cinerea*) are furnished with a coronet of spines, forming a receptacle for the egg which is deposited immediately afterwards. Sometimes, one end of the egg is provided with a sort of cap or lid; at other times the egg is in one piece, and the enclosed larva must gnaw or burst through it. The color is very various, although white, yellow, and green are the most prevalent tints.

In many species the eggs are deposited singly; in others, they are discharged *en masse*. Some arrange them symmetrically, and others enclose them in a mass of gluten, especially those whose larvæ inhabit the water. Many species employ a gummy matter to attach them firmly to the substances on which they are placed; while some, as the yellow-tail moth (*Arctia chrysorrhæa*), wrap them in a coating of down, which

they pull off their own bodies; and the lackey moth (*Lasiocampa Neustria*), deposits her eggs in a spiral coil round the stems of fruit trees.

Most varieties require to be viewed as opaque objects under a power of 30 to 60 diameters.

Elytra, or wing-cases of insects, are often singularly engraved and colored, and form the most brilliant of all opaque objects. Some are covered with beautiful iridescent scales, and others are furnished with branched hairs. Some of them are much improved by being mounted in a thick cell with Canada balsam, while others lose much of their splendor by being so treated. In order to ascertain whether an elytron will be improved by the balsam, one of the legs, or some part supplied with a few of the iridescent scales, should be touched with turpentine; if the brilliancy be increased, it may be mounted in balsam, if otherwise, dry. The elytra of some beetles, after having been softened in caustic potash, may be mounted between flat glasses, as ordinary objects.

Eyes of Insects, Arachnida, &c.—The structure, number, and form of the eyes of insects may be ranked among the most curious parts of natural history. They are generally hemispherical, on each side of the head, but sometimes they are oval or kidney-shaped. When closely examined, they are found to consist of a vast number of minute lenses, generally hexagonal, but sometimes quadrangular or circular. In the ant there are 50 of such lenses in each eye; in the common house-fly 4000; in the dragon-fly 12,500; and, according to Geoffroy, in the eye of a butterfly 34,650. When one of the eyes is detached from the head and cleaned, the lenses are found to be as clear as crystal. If a cluster of eyes be placed under the microscope, at a distance without its focus equal to their focal length, the lens of each eye will exhibit a distinct image of a candle, &c., placed before it.

The external form of the eye may be seen in situ in all insects when viewed as opaque objects, but the layer of lenses requires the aid of maceration and dissection to free them from a considerable amount of pigment. They may then be mounted dry, in fluid, or in balsam. If required to be flat, they must be made so by pressure while soft, otherwise they are liable to split.

If the eye of a fly, or other insect, properly prepared by mounting in balsam, be held near the eye of an observer who looks through it at a distant candle, &c., the interference of light in the minute lenses will cause a number of images to be perceived, tinged with beautiful colors.

The eyes of spiders are single. They have from four to twelve, variously arranged. Some insects have also single eyes in addition to the compound eyes before noticed.

Feet.—The structure of the feet of those insects which support themselves on polished surfaces, and against the force of gravity, is very remarkable, and it is doubtful if it be yet perfectly understood. Some suppose them to act as suction-pads, others that they secrete a viscid fluid by means of which they stick with sufficient force to enable them to walk. The latter theory is rendered most probable by microscopic researches.

The number of pads on each foot is variable.

The anterior and middle pairs of feet of the male Dytiscus are furnished with curious disc or cup-shaped appendages on the inside of the leg. They may be viewed as opaque and in balsam.

Hairs of Insects, &c., may be mounted dry, in fluid, or in balsam. In some spiders the hairs are branched; in the larvæ of many insects they are covered with spines, as the hairs of caterpillars, &c.; and in the crustacea they are provided with spines, or plumed like a feather. The hairs and scales of insects will be further treated of in the chapter on Test Objects.

Heads, Mouths, &c.—The manducatory apparatus of insects is a subject of great interest to the entomologist. The division of insects into Mandibulata and Haustellata are founded thereon; the first having jaws, the latter a proboscis or sucking instrument. Some of them require but little preparation, and may be mounted as opaque objects; others, as the probosces and lancets of flies and bees, demand considerable skill to display them to the best advantage. When thin and transparent, they should be mounted in fluid, but if thick and opaque, in balsam. Before mounting in the latter way, they should be dissected while soft, and laid out on a slide to dry.

Parasitic Insects should be placed in spirit and water in order to kill them. They may be mounted in fluid or balsam. Some of the large kinds may be examined as opaque objects. The term Epizoa has been applied to them because occurring on the exterior, in contradistinction to those occurring within animals, which are called Entozoa. Some of them are classed with insects, as having six legs; while others, having eight, are called Acari, and are included in the class Arachnida.

Some very minute insects, called Aphides, are abundant on plants, the leaves, &c., of which they destroy. Others, called Cynips, are the cause of the excrescences on the leaves, &c., of trees, termed galls. The well-known oak-apple is produced by the *Cynips quercus*, which is a most elegant object when examined by reflected light. The same may also be said of the insect from the gall of the rose. Gather the galls when ripe, and place them in a box covered with gauze. In a few days or weeks numbers of insects will escape from the gall, and those exhibiting beautiful colors may be selected.

Among the Acari, may be mentioned the cheese-mite, *A. domesticus*, and the itch-insect, *A. scabiei*. To obtain the latter, the operator must examine carefully the parts surrounding each pustule, and he will generally find in the early stage

of the disease, a red spot or line communicating with it; this part, and not the pustule, must be probed, and the insect, if present, be turned out. It is often, however, difficult to detect its haunts.

To obtain the *Entozoon folliculorum*, which is a parasite occurring in the sebaceous follicles of the skin of the forehead, nose, &c., squeeze the neighborhood of the little black spot or pustule, so as to force out the sebaceous or oily matter. This should be laid on a slide, and a small quantity of oil added to separate the insects from the nidus in which they are imbedded. They may then be transferred by a pencil-brush to a clean slide, covered with thin glass, and mounted.

Another species of Acarus, the harvest-bug or tick, *A. autumnalis*, is a very painful source of irritation to the skin wherein they may have insinuated themselves. They may be dislodged with a needle, and mounted in fluid or balsam.

Tracheæ and Spiracles of Insects.—The respiratory system of insects will be described in the chapter on Dissections, together with their nervous, digestive, and circulatory systems. The manner of mounting them has been described.

Stings, Ovipositors, &c., frequently require considerable care in dissection. They may be mounted in fluid or balsam. In order to prepare them, the abdomen should be laid open by a slit along the back of the insect, in order to obtain a view of the relations of the various parts; then the posterior segment should be fixed to a loaded cork under water and dissected beneath a shallow magnifier. The dissection should be made from right to left, proceeding from without towards the interior, as far as the median line, when it should be continued from within outwards. This mode of dissection may also be advantageously employed to display or procure other objects of interest. See the chapter on Dissecting Objects.

Shells of Mollusca.—The structure of shell has only

lately attracted the attention of microscopists, but since the year 1842 the subject has been scientifically investigated by Mr. Bowerbank and Dr. Carpenter. According to the experiments of the latter gentleman, undertaken at the request and expense of the British Association, the calcareous matter in all shells is nearly equally crystaline in its aggregation, and the particular forms which their fracture presents are determined chiefly, though not entirely, by the arrangement of the animal basis of the shell, which possesses a more or less highly-organized structure.

All thin sections of recent shell are translucent, except when the coloring matter is opaque, or when the calcareous matter is deposited in a chalky state between the true laminæ of the shell, as in the oyster.

Dr. Carpenter classifies shells, into—1. Prismatic cellular structure, as exemplified in the *Pinnæ*. 2. Membranous shell substance, as the *Mya*, *Anatina*, and *Thracia*. 3. Nacreous or pearl structure, as the inner surface of some species of *Ostrea* and *Mytilus*. 4. Tubular structure, as the outer layer of *Anomia Ephippium*, *Lima scabra*, &c. In some cases the tubes run at a distance from each other obliquely through the shell, as in *Arca Noæ*. 5. Cancellated structure. Examples of this latter division, which somewhat resemble the cancelli of bone, are only met with in certain fossil shells.

Shell should be examined microscopically in three ways: by reflected, transmitted, and polarized light. For the first, fragments of shell will suffice; for the others, thin sections, cut both vertically and transversely, are necessary. To exhibit the animal basis of shell, specimens may be treated in the manner recommended for coral.

Scales of Fish.—M. Agassiz has arranged the class of fishes into four orders, according to the structure of their covering, as follows:

Enamelled Scales.

1. *Placoïdians.* Cartilaginous fishes, having prickly or flattened spines, as the skates, dog-fish, and sharks.

2. *Ganoïdians.* With angular scales composed of horny or bony plates covered with enamel, as the sturgeon, and bony pike. Fifty out of sixty genera are extinct.

Scales not Enamelled.

3. *Ctenoïdians.* Scales notched or serrated on their posterior free edges, as the perch.

4. *Cycloïd* fishes, with smooth scales, more or less circular, and laminated, as the herring, salmon, &c.

Among the various kinds of fish-scales selected for microscopic objects, those of the eel are much prized, as it was formerly considered that it had no scales. They may be obtained from the under surface of the skin with a knife or a pair of forceps.

Some scales when viewed by polarized light have a brilliant effect. They may be mounted in balsam. Fossil scales, as well as others, may be examined as opaque objects.

Hair of Animals, etc.—Hairs are composed of an aggregation of epithelium cells, and the color depends upon the quantity of pigment deposited in or about each cell. They may therefore be called elongated developments of the epidermis. A transverse section is not always round, but may be oval, flattened, or reniform. Henle has shown that the curling of hair depends upon its form, and that the flatter the hair the more it curls, the flat side being directed towards the curve described. P. A. Browne, Esq., of Philadelphia, has attempted to show a specific difference in the races of men from the shape of the transverse sections of their hair, but we think without success. It is not likely that scientific investigation will ever

overthrow the assertion of Scripture, "God hath made of one blood all nations of men."

Care should be taken to select both the hair and the wool from each animal, as they differ materially in their structure; the finer kind, or what is known as wool, being endued with the property termed *felting*, which property is of considerable importance in a manufacturing point of view. The felting property is owing to the imbricated scales on the outside of each hair. In the adult human hair this structure is not very apparent, but may frequently be seen in fine specimens from very young infants. These, however, should not be mounted in balsam.

The smaller kind of hair may be mounted dry or in fluid; or, if of a dark color, in balsam. Horizontal and vertical sections should be made of large hairs and spines, which may be done after gluing a number together, in the same way that sections of wood, &c., are made.

Sections of horns, hoofs, quills, whalebone, spines of echini, &c., are all interesting objects.

ANATOMICAL OBJECTS AND PREPARATIONS.

Blood.—To examine this vital fluid, it is necessary to place upon a glass slide a small drop recently taken, and cover it with a thin glass or piece of mica. The blood-corpuscles may also be preserved in Dr. Goadby's A 2 fluid, or prepared by drying rapidly on the slide and covering with the thinnest glass.

The red corpuscles in man are of a circular flattened form. If water be added to them, they become spherical by endosmose. Their appearance varies as they are viewed a little in or out of the focus of the microscope; in one place showing a

nucleus or spot in the centre, and in the other a thickened edge, like a ring (*a*, Fig. 28). In all air-breathing, oviparous, vertebrated animals, the blood-corpuscles are oval, and a nucleus may be observed within each of them. This nucleus is rendered very distinct by the addition of a drop of diluted acetic acid.

The observations of Professor Owen on the blood-discs of the *Siren acertina*, *b*, Fig. 28, show that the nucleus consists of a cluster of nucleoli enclosed in a capsule in the centre of the oval blood-disc. The length of the disc in the Siren is $\frac{1}{450}$th of an inch, while the diameter of human blood-discs average $\frac{1}{3000}$th of an inch.

Fig. 28.



Very frequently, under the microscope, the blood-corpuscles unite by their flat surfaces, so as to form rows, like piles of coin; the disposition to which is proportionate to the quantity of fibrin in the blood.

When the corpuscles are observed in a drop of blood spread out between two plates of thin glass, they will often be seen to present a tuberculated or mulberry appearance, which is supposed by Donné to depend upon commencing desiccation, and to arise from deficiency of serum. Others ascribe it to evaporation from the edge of the slide. In many of my own observa-

tions the globules presented a compound appearance, consisting of several granules, one in the centre, with the others disposed around it; the regularity of which appearance seems to intimate its connexion with the structure of the corpuscle.

Circulation of Blood may be seen in the web of a frog's foot (see page 47); in the fin or tail of a fish; and in the legs, &c., of many spiders and insects, especially aquatic larvæ. There is nothing so wonderful and pleasing as the sight of the blood-corpuscle coursing through the vessels in the web of a frog's foot, when seen with a power of about 200 diameters. The researches of Kaltenbrunner, a distinguished German pathologist, on the circulation of blood in a frog's foot, and the influence of various irritants upon it, as seen under the microscope, have added much to our knowledge respecting congestion and inflammation, and are of the highest interest to the practitioner and student of medicine. They are referred to by Dr. Watson in his preliminary lectures on the Practice of Medicine, and their importance clearly shown.

Hassal remarks, that the circulation of blood is seen to the greatest advantage in the tongue of a frog. For this purpose the frog should be secured by a bandage to a thin flat piece of cork, &c., which is perforated at one extremity by a square aperture. To this aperture the mouth of the frog should be secured, and the soft, pulp-like tongue being drawn out by a pair of forceps, and spread out over the aperture, may be retained in position by pins. The piece of cork (answering instead of the frog-plate) should then be fastened to the stage of the microscope.

In the view of this structure, we have displayed in action various parts of the animal organization; arteries, veins, nerves, muscular tissue, epithelial cells, and glands. [*Microscopic Anatomy.*]

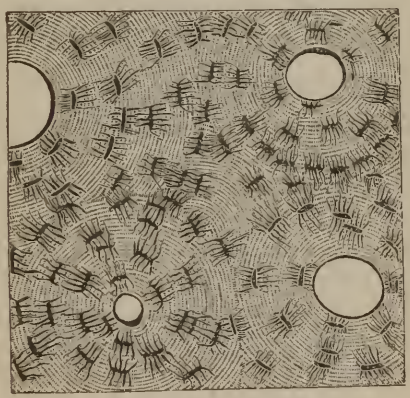
Bone should be cut into thin sections, about $\frac{1}{50}$th of an inch in thickness. They can be cut with a fine saw, such as are

made of watch-spring. They should then be cemented on a piece of glass; filed to the proper thinness; ground upon a hone; and polished by a leather strap or piece of cloth charged with putty powder (oxide of tin and lead), or carbonate of iron (rouge). They may be mounted dry or in balsam. Both transverse and longitudinal sections should be made.

The sections may be cleaned from grease by soaking in sulphuric ether.

The bloodvessels of bone when injected are rendered more conspicuous if the earthy parts of the bone are removed by means of an acid. They may then be kept in oil of turpentine, which renders the tissue more transparent.

Fig. 29.



When animal tissues are consolidated by the deposition of earthy matter within their cells and fibres, a hard, solid substance is produced. Sometimes the earthy matter crystallizes, as in the teeth; at other times it combines chemically with the gelatine of the cells, as in bone. This deposition in bone

does not occur in all the cells, as the bone requires to grow and be nourished; hence arises its peculiarity of structure. Independently of its hollows, or cancelli, the hard part of the bone is traversed by canals, called Haversian, which run in the direction of the laminæ; these are connected by transverse communications. In a thin transverse section of bone, the solid matter may be observed arranged around the Haversian canals in concentric rows (Fig. 29). Among these layers dark specks are dispersed. These dark specks (called *lacunæ*, or *corpuscles of Purkinje*), when magnified about 200 diameters, are observed to be cavities of an irregular, oval form, from which emanate numerous minute branch canals. These cavities appear dark for the same reason as a minute air-bubble does in Canada balsam,—namely, the difference of refraction of the two media. By means of these branches (*canaliculi*), lacunæ, and Haversian canals, the bone is nourished with proper fluids.

It has been shown by Mr. J. Quekett, that there are differences in the form and size of the lacunæ, in the various classes of animals, sufficiently characteristic to allow of the assignment of minute fragments of bone, with the aid of the microscope, to their proper class. The lacunæ of reptiles are distinguishable by their large size, and long oval form; and those of fish, by their angular form and the fewness of their radiating canaliculi. The lacunæ of the bird may be distinguished from those of the mammal, partly by their smaller size, but chiefly by the remarkable tortuosity of their canaliculi. It is worthy of remark, also, that the sizes of the lacunæ in the four classes of vertebrata, bear a close relation to the sizes of their blood-corpuscles.

Sections of Teeth may be made in the same way as bone. Some should be soaked in hydrochloric acid, to destroy the earthy matter, and others in caustic potash, to get rid of animal

matter. These should be mounted in fluid, the others dry, or in balsam.

A tooth consists of three distinct structures, the relative proportions and arrangement of which constitute the chief differences in the teeth of various animals. 1. Enamel. This is crystallized phosphate of lime, deposited in the form of long prisms each about $\frac{1}{3000}$th of an inch in diameter, produced in animal cells which are almost obliterated when the tooth is fully formed. In human teeth a coating of enamel is formed over the crown of each. In the teeth of some animals the enamel is disposed in vertical layers among the other structures of the tooth. This is especially the case with the grinding teeth of large herbivorous animals. 2. Dentine, or Ivory. This forms the principal substance of which the teeth are composed. The amount of animal gelatine in it is often very considerable. The earthy matter is usually deposited in the form of fine branching cylindrical tubuli, radiating from the centre of the tooth. These tubules have been successfully injected with coloring matter by soaking the tooth in a solution of Saunder's wood, &c. On the ends of the dentine tubuli are placed the ends of the enamel prisms, in the human tooth. Dentine is now established by Professor Owen as an ossification of the pulp of the tooth. 3. The bone or Cementum, of teeth, is composed of a mass of earthy matter and cartilage, having minute cavities or bone-corpuscles and calcigerous canals.

Sometimes a vertical section is made of a tooth *in situ*, exhibiting a section of the jaw with its cavities for the nerves and vessels, as also the manner in which the alveolar process which forms the socket is constructed. Both vertical and transverse sections should be made.

Skin.—The skin is supplied with a very rich capillary network; and also provided with two or more sets of glands, one for secreting the perspiratory fluid, the other an unctuous

or sebaceous matter for lubricating the skin itself. Taking the human skin as an example, we should commence the study with vertical sections, made through parts supplied both with hair and papillæ. The perspiratory glands are best seen in the soles of the feet, and palms of the hands; the sebaccous glands should be examined in parts about the face or chest, where hairs are numerous; these latter sections will also show the roots of the hairs and the hair follicles. The skin may be rendered firm enough for vertical section by hardening in a saturated solution of carbonate of potash or in strong nitric acid.

The *epidermis* may be separated by maceration in water, or by plunging the skin into water nearly boiling hot. Great care must be taken in separating it in order to see the cœcal prolongations sent by it to line the sebaceous crypts, bulbs of the hairs, &c.

The capillary network of the *cutis vera* may be seen in injected specimens when the cuticle has been removed, which will often require the aid of maceration for the purpose. If the skin be that of a black man, care should be taken in the removal of the cuticle, as in it may be examined the *rete mucosum*, or colored layer, which consists of a series of minute hexagonal cells, containing pigment. The same structure may be seen in the skins of animals whose hairs are black; for this purpose the lips of a black kitten, when injected, should be selected, as in them the mode of growth of the young whiskers, their copious supply of bloodvessels and nerves, and various other points of interest, may be observed. The papillæ are best shown in the extremities of the fingers and toes, when injected; the cuticle which invests them should also be mounted as an object, with its attached or papillary surface uppermost, as in this the grooves for their lodgment, together with the openings of the sudoriferous glands, can be well seen.

The two layers of integument in insects, &c., may be sepa-

rated mechanically, or by maceration in dilute hydrochloric acid.

Eyes.—Many objects of interest may be obtained from the eyes of various animals; as the crystalline lens, the pigment, the ciliary processes, the retina, and the membrane of Jacob. The structure of the crystalline lens in fish is best seen after the lens itself has been hardened by drying, boiling, or long maceration in spirit. After having peeled off the outside, the more dense interior will be found to split up into concentric laminæ, and each lamina will also be found to be composed of an aggregation of toothed fibres; these are best seen when mounted in fluid, but if dyed, they will show very well in balsam. The pigment is easily obtained by opening a fresh eye under water. It may then be detached as a separate layer, and parts of it floated on slides to dry, after which they may be mounted in balsam. The ciliary processes are best seen when injected; they should be mounted in a convenient cell with fluid, and viewed as opaque objects. The retina should be examined from a very fresh eye, between glasses, and a little serum or aqueous humor added, to allow the parts to be well displayed; but water must be avoided, as the nervous matter will be considerably altered by it; the membrane of Jacob will also require the same precautions, but the vascular layer of the retina, when injected, may be well seen after having been dried.

For the dissection of the eye, the plaster mould, described in the chapter on Dissecting Objects, will be found useful. The eye may be fixed to the plaster by bent pins while it is yet fluid, as otherwise it would not remain firm. Sometimes the eye is frozen, to facilitate dissection.

Muscular Fibre.—Muscles are of two kinds, voluntary and involuntary; from their functions. The voluntary muscles of all the vertebrata, and the articulate animals (as insects,

&c.), have their fibres marked with transverse striæ. The involuntary muscles are not so marked. These marks are supposed to point out the ultimate corpuscles or cells of which the fibrillæ are composed. The general opinion is, that the juxtaposition of cells is the true form of the ultimate fibre. Several microscopists, however, of some note, believe the fibre to be spiral, and enclosed in a membranous sheath. Others have thought the transverse striæ to be due to a corrugation of the fibre. In my own examinations I have met with cases where the structure appeared to be a bead-like fibre wound spirally into a tube, or around a central unmarked fibre; yet other observations, especially with polarized light, show a longitudinal arrangement of cells. Perhaps the true structure is a compound of both these modes; the sheath being spiral, and the ultimate fibre longitudinal. If we should state that the ultimate granules or cells of muscular substance are arranged in fibres, and that a number of such fibrillæ are enclosed in a spirally corrugated sheath, a number of such bundles being united together; the description would correspond with the majority of observations.

A small portion of muscle, freed from cellular tissue, may be put on a slide with some kind of fluid, placed under the dissecting microscope, and the fibres torn asunder with fine needles. It should be preserved in fluid under a thin glass cover.

The nerves of muscle may be displayed in a thin layer of delicate fibres which form a part of the abdominal wall of a frog, by employing a compressorium. The capillary blood-vessels may be seen when injected. By the use of the compressor, the thin recti muscles of the eyes of small birds, if seen soon after death, will, without injection, show both nerves and capillaries.

Nerve.—The dissection of nerves, to show their ultimate structure, is similar to that of muscle, above described. It

should be performed, however, in a little serum or white of an egg; as water, &c., changes its appearance. As soon as the true structure has been well seen, water, ether, &c., may be added, to show how much they change its original appearance. In all examinations of nerve or muscle, the more delicate the structure, the sooner after death should it be dissected. Dr. Stilling recommends to place the spinal cord in weak spirit for twenty-four hours, after which it may be successfully steeped in stronger spirit, before sections are made. He directs the sections to be made with a razor whose surface is moistened with alcohol.

Fibrous and Areolar Tissue.—Nearly allied to involuntary muscular fibre is a fibrous tissue termed the yellow or elastic; this is often found in connexion with another, finer and less elastic, and called, from its color, the white fibrous tissue; a mixture of the two is known to anatomists as the areolar tissue, and is largely used in the animal economy, as it forms a support for all the vessels, nerves, and muscles, from either of which it may be easily procured. The yellow tissue is found in nearly an isolated condition in the ligamentum nuchæ of the necks of some animals, especially of the ruminating tribe; it also enters largely into the formation of the intervertebral discs. A portion of the ligament from the neck of a sheep or calf, even after boiling, will exhibit the elastic fibres exceedingly well; they are of nearly uniform size, generally curled at their extremities, and of a yellowish color. They may be prepared as muscle or nerve, with the needle points.

Cartilage.—Consists of cells, contained in cavities which are formed in a solid and hyaline intercellular substance. (Fig. 41). In fibro-cartilage, instead of homogeneous intercellular substance we meet with elastic fibres. The structure is easily examined by making thin sections.

If any of the above tissues are to be kept, they should be mounted in fluid, as spirit and water, or the creasote liquid.

Mucous and Serous Membrane.—Mucous membrane is the investment of all the internal parts of the body, continuous with the skin. Every cavity, organ, or gland, which opens on the surface, is lined by it. Shut sacs are lined by serous membrane.

These membranes may be divided into two parts: the epithelium, and the basement membrane. The external skin is evidently a similar structure, somewhat modified, and is capable, under certain circumstances, of taking on a similar function. The epithelium of skin is the cuticle or epidermis, but the basement membrane, though present, is not easily shown, except where the surface is raised into papillæ.

The epithelium exists in three varieties: the scaly, prismatic, and spheroidal. The first kind is most largely developed in the skin; the cuticle, with its horns, hairs, hoofs, and feathers, &c., is made up of it. Detached scales may be obtained from the inner side of the mouth or by scraping any of the serous membranes gently with a knife. The prismatic; or according to Dr. Todd, the columnar; is abundant throughout the stomach and intestines, and even the lungs. Each prism is attached by its sides to its fellows, and endwise to the basement membrane. The attached extremity is generally pointed, the free one wide and flat, and covered with vibratile cilia, which may be often observed in rapid motion, some time after the death of the animal. The third variety, or spheroidal, is to be met with in all glandular structures, as the tubes of the stomach and kidney, and the secreting structure of the liver.

The basement membrane is structureless, and is not supplied in any way with vessels. The best places for viewing it are the tubes of the kidney and stomach, and the villi of the small intestine. It is supported upon a submucous areolar tissue, in

which both the bloodvessels and nerves ramify, but do not in any case enter the membrane itself.

In order to examine the surface of mucous membranes, the mucus should be washed off as gently as possible, by a small stream of water or a small syringe. If the epithelium be required, it may be detached from the surface with a scalpel, placed on a glass slide, and viewed as a transparent object, with a power of 200 diameters. The mucous membrane itself may be seen by reflected light while under water; a movable dissecting microscope being brought over it. In order to obtain a correct idea of the external surface, sections, both horizontal and vertical, should be taken and submitted to high powers. When the membrane cannot be well cut into thin slices, it may be separated with the needles, or by slight pressure in the compressorium. Where epithelium is so abundant as to form a layer of cuticle, it must be removed by maceration, in order to see the mucous surface.

The arrangement of the capillaries, as seen in the injected mucous membranes, is exceedingly interesting and forms a numerous class of preparations.

Ciliary Movement.—If the roof of the mouth of a living frog be scraped with the end of a scalpel, and the detached mucous matter placed on a glass slide, and examined with a power of 200 diameters, the epithelium cells, and the movement of their cilia, may be well seen. The most common method is, however, to cut off with a pair of fine scissors a small portion of the gills (branchiæ) of an oyster or mussel; lay it on a slide or on a tablet of an animalcule cage, with a drop or two of the fluid from the shell. With the needle-points separate the filaments from each other, and cover it lightly with a thin piece of glass. The cilia may then be seen in several rows, beating and lashing the water with amazing activity. If fresh water be added instead of that from the shell, the movement

will speedily stop. The motion and structure of the cilia is sometimes better observed after the lapse of some hours, as the movement will then have become sluggish.

Sometimes the ciliary movement may be witnessed on epithelial scales found in the mucus taken from the nasal passages during a slight catarrh.

Injected Preparations.—For the mode of making these preparations, the reader will refer to the chapter on Minute Injections.

There can be no doubt but that the blood is, *par excellence*, *the* vital fluid. From it is derived the material for the development of each part of the organization; nerve as well as muscle, bone, tendon, &c. Even unnatural and morbid growths must have their origin in some alteration in this all-pervading, all-sustaining fluid. "The life thereof is the blood thereof."

The capillary vessels of the body form the vehicle of vital distribution and stimulus. By them is conveyed the nutrition of all the tissues; and through them all foreign substances are extracted, and the blood thus rendered pure and vital. By endosmotic action through their thin coats in the lungs, oxygen unites with the carbon, and probably the iron of the blood, and carbonic acid gas is expelled; and from their peculiar arrangement in the kidney, lobules of the liver, &c., effete matters are strained, as it were, from the circulation, and carried off.

But there is another function, of equal, if not superior, importance with those just mentioned, which, in the judgment of the author of this work, the capillaries are destined to subserve. They are, doubtless, the cause, perhaps the sole cause, of the difference in the sensations experienced in the various organs and tissues of the animal frame, under the stimulus of the varied excitants to which the organization is subject in health and disease. The nervous cords may transmit impressions to

the sensorium, but it is the stimulus of the blood—the vital fluid—variously modified by the capillaries, which determines the character of those impressions. Hence we find that those parts which are but slightly supplied with capillary vessels are comparatively dull of sensation, and *vice versa*. How otherwise can we account for the different sensations produced by inflammation in different tissues? as for instance, the burning, pungent pain of inflamed skin, contrasted with the dull, aching sensation of inflammation in the fibrous tissue.

May not the peculiar and delicate arrangements of the capillaries in the different coats of the eye; the ear; the papillæ of the skin; and other organs of special sense, be referred to the same design?

Other physiological facts also tend to establish this view. "If the abdominal aorta be tied, the muscles of the lower extremities will be paralysed, and on removing the ligature, and allowing the blood to flow, the muscles will recover themselves." (*Todd and Bowman.*) We know, too, that the stimulus of too much, or too rapid, blood on the brain, will produce delirium, and illusions of special sense:—impressions being made on the sensorium independent of the action of usual external stimuli.

The theory above referred to, in order to explain or account for these phenomena, may be expressed as follows:—The principle of life, or the capacity for vital action, is a property impressed by the Great Creator upon the material organization of both animals and vegetables. In addition to this, the properties of sensation and volition have been imparted to all animals. These properties point out the existence of a spiritual being or entity (distinct from vital organization), which holds its connexion with each part of the animal frame by means of the nervous system. It is, however, essential to the integrity of this connexion, and to the proper performance of the func-

tions of volition and sensation, that the nerves should be supplied with the proper vital stimulus of the organization—the blood—and the mode in which this stimulus is supplied, will determine the character of the impressions made upon, or received by, the entity or being referred to.

This entity, which some have confounded with the vital principle, acts through the nerves in a manner peculiar to itself. The force or material by which it holds connexion with the bodily frame is not electricity, although in some respects its properties are analogous. Messrs. Todd and Bowman present the following arguments, which prove conclusively the last remark. They show that the electric fluid could not be sufficiently insulated in the minute nerve-tubes to enable them to be proper conductors—that the most delicate tests of electricity fail to discover it, when applied to nerve in action—that a ligature to a nerve stops the propagation of nervous power, but not of electricity—that if a piece of nerve be cut out and be replaced by an electric conductor, electricity will be transmitted when applied, but no nervous force excited by stimulus above the section will pass to the parts below—and that both nerve and muscle are infinitely worse conductors of electricity than copper or other metals. These facts are clearly opposed to the present popular theory of the identity of nervous force and electricity.

More extended remarks upon our theory of the cause of sensations would be out of place in a work of this kind; yet as the varied shapes and arrangement of the capillaries must be demonstrated by means of the microscope, and as we have seen no theory which attempts to explain the design of such variations, an allusion to this seemed to be appropriate.

Hassall, in his Microscopic Anatomy, records an instance of the capillary circulation being maintained for hours in a mutilated portion of a frog's tongue, which had been entirely sepa-

rated from the rest. A similar instance came under the author's own observation, in a thin slice from the kidney of a mouse, which had been dead for some hours. An account of it was published in the Philadelphia Medical Examiner for December, 1851, pp. 767–770.

The frontispiece represents some of the forms in which the capillaries are arranged. Fig. 1, represents the injected capillaries of muscular tissue, after Gerber, and a preparation of the author's.

Fig. 2. Injected lobules of adipose tissue, from the skin of a pigeon: the lower part of the figure shows a portion of the same, magnified 200 diameters, from Quekett's Histology.

Fig. 3, is a vertical section of the injected skin of a dog's foot, showing the vessels of the sensitive papillæ, and of the adipose tissue beneath. From an injection by Topping, in the author's possession.

Fig. 4, exhibits a small piece of injected mucous membrane, from the small intestine of man. The villi appear to lie flat, on account of the preparation being mounted in balsam and covered with thin glass. This is one of the most beautiful of the author's preparations. Not only are the villi well injected, but a conglomeration of flask-like cœca, or glands, are well seen, having the minute vessels which ramify upon their sides exhibited.

Fig. 5, is from a specimen of injected liver, by Topping.

Fig. 6, represents the capillary vessels which ramify among the air-cells (sections of bronchial tubes?) in the human lung.

Fig. 7. Injected papillæ of the tongue.

Fig. 8. Injected ciliary processes of the eye.

Fig. 9. Injected Malpighian bodies from the kidney.

Fig. 10. The muscular coat of the small intestine, from Gerber, after Lieberkühn.

Figures 11 and 12, represent the most common modes of termination of the arteries, either looped or branching—after Gerber.

CHAPTER VII.

TEST OBJECTS.

The discovery of this class of objects by Dr. Goring, a full account of which may be found in Mr. Pritchard's works on the Microscope, was the chief cause of the modern improvements in the achromatic compound microscope.

Mr. Pritchard, following Dr. Goring, divides test objects into two classes, viz., tests of the penetrating power, and tests of the defining power of the instrument; the first showing its destitution of spherical and chromatic aberration, and mechanical imperfection; and the other class showing its angle of aperture.

This distinction is not now necessary, as few persons, save those engaged in the manufacture of object-glasses, attend to the former, the improvement in achromatic object-glasses having been so extensive that a good instrument, in this respect, is readily procurable. Still, it may be well to give an outline of the means by which the presence or absence of achromaticity may be known.

Chromatic aberration is rendered sensible by almost any transparent object, when the light falls upon it obliquely; but more especially by such as are not transparent, but only illuminated by intercepted light, of which a very good example may be seen in a piece of fine wire sieve, treated like a diaphanous object, also in a thin plate of metal perforated by very small holes. The various colors are seen according to the

order of their refrangibility, by putting the object both within and without the focus, as well as by viewing it at the focal point

Spherical aberration is most sensibly felt in viewing opaque objects, especially if of the brilliant class. It shows itself in a variety of ways: first, as a diffused nebulosity over the whole field of view; secondly, as a confined nebulosity, extending only to a certain distance from the object; and thirdly, in a want of sharpness and decision in the outline caused by a penumbra or double image, which can never be made to lap perfectly over the stronger or true one. Destitution of spherical aberration is evinced by the absence of these appearances, and by the vanishing of the image immediately that the object is put out of focus either way.

To ascertain the defects alluded to above, a minute globule of mercury on a black ground, known as an "artificial star," is used. It presents a very minute point of light. Very minute globules of mercury, spread over a blackened surface, are viewed as opaque objects, being illuminated by the light from a window or lamp thrown on them by a condensing lens. When one of these globules is in the focus of a single lens object-glass, a strong coma surrounds the miniature image of the window seen in the globule, and when within or without the focus, the light of the window swells out into a circular disc. These appearances are more or less accompanied by prismatic colors.

When an achromatic combination, perfectly corrected for both kinds of aberration, is employed, the globule should exhibit similar appearances both within and without the best focus; and when at the focus, the point of light should be seen as a minute dise, free from irradiations and color, except a general blueness, which results from the irrationality of the spectra of the different glasses of which the object-glass is composed.

Power of definition depends, in a great measure, upon the angle of aperture of the object-glass. A deficiency of angular aperture is shown by a want of light, producing unsatisfactory vision, which is rather increased than ameliorated by augmenting the intensity of the artificial illumination; by an incapacity of showing lined objects, except such as are of the lowest class; and by giving very large spurious discs with artificial stars; also by showing easy test objects with the lines faint, while the spaces between them are darker and more opaque than they ought to be.

When the aberrations are properly corrected, and the angle of aperture considerable, the lines on test objects become fine, sharp, and dark, and the spaces between them bright, provided the illumination has been properly conducted; they moreover become visible in a very faint light; the outline and the lines are seen at once; and the spurious discs of all brilliant points are very sharp and small.

In order to explain more fully what is meant by angular aperture, let A and *a*, Figs. 30 and 31, represent two objects, in all respects alike; and suppose B, B, and *b*, *b*, to be two object-glasses of equal focal length; the former a single lens, of the best construction, such as was used in the old compound microscope, and the latter a lens of the newest form, termed an achromatic. Now these object-glasses will form their respective images at I and *i*, and they will be of equal dimensions. But if the number of rays proceeding from A and falling upon the single lens B, B, is not enough, when collected at I, sufficiently to stimulate the eye, any minute pore, stria, or other marking at A, will not be rendered visible; while from the increase of aperture in *b*, *b*, allowing much more light to be transmitted, every mark at *a*, will be represented at *i*, and the eye being powerfully acted on by the increase of light, will be highly sensible of it.

The angles B, A, B, and *b*, *a*, *b*, are the angles of aperture of the respective object-glasses, and the quantity of light transmitted will be as the squares of B, B, and *b*, *b*, their focal length being equal.

Fig. 30.

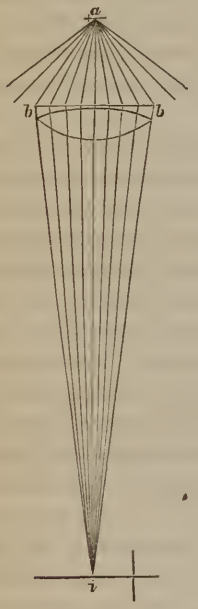
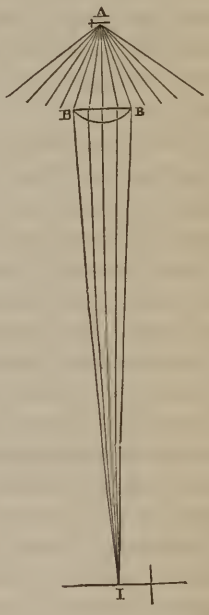


Fig. 31.



It may be supposed, that if we throw more light upon an object, so that more may be collected by the object-glass, we shall be better able to define its structure; and this would probably be the case if we could throw light only upon those minute parts which we wish to examine, and not upon the whole object, but as we cannot increase the relative proportions of light, the advantages proposed cannot be derived.

In examining test objects it will be well to remember that there are generally some very easy ones, even among samples of the most difficult kind. The darker the specimen, the more easily is it made out; and the more transparent the tissue, the greater difficulty there is in developing its structure. Great attention too should be paid to the proper illumination of the object, or a superior instrument will be undervalued.

The following list affords an account of those objects most frequently used as tests of the defining power of the instrument.

Bat's Hair.—This is a most beautiful structure, presenting a series of scale-like projections arranged in the form of a whorl around the central part or shaft. They are least numerous at the base of the hair, and increase towards the apex.

Mouse Hair differs materially from the other in size and structure. Their internal structure is cellular, there being three or more rows of cells in each hair, the color of the hair depending on the pigment within the cells. Under the microscope all hairs should have their light or transparent parts clearly and distinctly separated from the darker portions, and it is from the sharpness with which the parts are separated that a correct opinion of the value of an instrument can be obtained.

In selecting hair of animals for examination, the lightest colored should be preferred. Like the scales on insects, the hair from different parts of the same individual varies considerably in structure.

Hair of the Dermestes.—This very remarkable hair is obtained from the larva of a small beetle, which preys on dried animal substances, as bacon and hams. It is covered with brownish hairs, the longest of which are selected.

The shaft of this hair is covered with whorls of close-set spines, and at the head is invested with a curious arrangement,

consisting of several large filaments or spines, which are pointed at their distal extremities, and provided with a protuberance at their proximal ends.

This object, with the others above noticed, is a good test of the defining power of a half-inch object-glass.

Scales of Insects.—The dust on the wings and bodies of butterflies, moths, and other insects, prove, on microscopic examination, to be scales or feathers, overlapping each other like the shingles on the roof of a house. They vary much in form and size; and from the difficulty of developing their structure, they form excellent test objects. In the present list the most easy are first named.

Lepisma Saccharina.—These silvery-scaled insects frequent closets, book-shelves, &c., and are very common. Their scales are very pretty objects, but are so easily made out as hardly to deserve the name of test objects. The longitudinal striæ appear to stand out in bold relief, like the ribs of a shell. A good glass should show well the contrast between the striæ and the interspaces.

Morpho Menelaus.—The pale blue scales from the upper surface of the wing of this splendid butterfly form a good test for the half-inch object-glass, which should show clearly the transverse as well as the longitudinal striæ, giving it a brickwork appearance. If the scale be flat, which is not common, the striæ should be seen over the whole surface. Sometimes the scales are damaged, the pigment having been removed; in such cases the cross striæ cannot be seen. The pigment, under very high powers, exhibits a dotted appearance between the striæ.

Tinea Vestianella, or Clothes Moth.—The scales of these insects are very delicate, and require some tact in the management of the illumination to resolve their lines distinctly. The small scales from the under side of the wing should be taken; the others are easy.

Pontia Brassica, or Common Cabbage Butterfly.—The pale, slender, double-headed feathers, having brush-like appendages at their insertion, are good test objects. The specimens which are easily resolved are short, broad, and more opaque. The striæ are longitudinal, and with a power of 500 diameters appear to be composed of rows of little squares or beads.

Podura plumbea, or Lead-Colored Springtail.—The body and legs of this tiny creature are covered with scales of great delicacy. The surface of each, under a power of 500 diameters, appears covered with numbers of delicate wedge-shaped dots or scales, arranged so as to form both longitudinal and transverse wavy markings. A very small scale is a good test of the defining power of a one-twelfth or one-sixteenth inch object-glass. The small scales may easily be rubbed off the scale to be examined, unless great care be taken in mounting, &c., and, of course, it will be useless as a test object.

Shells of Infusoria.—Several delicate species serve as test objects. The so-called longitudinal and transverse striæ are resolved by superior instruments into dots or bead-like projections from the surface. The *Navicula hippocampus*, *N. angulata*, *N. Spencerii*, &c., have been recommended as tests. A species marked *Navicula attenuata*, is a good object, requiring delicate illumination under a high power, in order to show the longitudinal striæ or dots. Several kinds of Tripoli may also be used for the purpose.

For examining the striæ on infusorial shells it is often very necessary to have an oblique illumination.

As it is always a tedious matter with the use of a high power to find a minute object on the slide under the stage, it will be most convenient to bring it first into the centre of the field by the use of a lower power, and afterwards substitute the high power object-glass.

Artificial Objects.—M. Robert, a Konigsberg optician,

has prepared glass plates, on which are ruled, with a diamond, systems of a hundred lines, which, 10 by 10, approach closer together, according to a certain standard. Ordinary instruments make out the 6th and 7th systems as separate lines. Superior instruments reach the 8th and 9th. No instrument has yet unfolded the 10th system of lines. This is certainly a great triumph of art.

CHAPTER VIII.

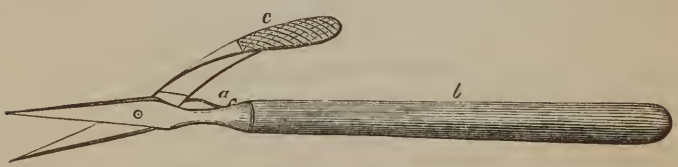
ON DISSECTING OBJECTS FOR THE MICROSCOPE.

Reference has already been made in Chapter V. to the manner of dissecting and preparing certain animal and vegetable tissues, yet much has been omitted, which may perhaps be more fully appreciated under the present head.

The instruments required in microscopic dissections, or minute anatomy, are various kinds of forceps, scissors, scalpels, needles, troughs, loaded corks, and arm-rests.

The forceps, in addition to the ordinary forceps used in coarse or rough dissection, may be made with closely-fitting, sharp points. The scissors are similar to those used for surgical purposes. It is useful to have a pair with the point of one of its blades blunt and truncated, for cutting open tubular parts, as the alimentary canal. Scissors with curved blades are also of service. A pair of very small scissors, whose

Fig. 32.



blades are kept open by a spring, *a*, Fig. 32, was much used by Swammerdam in his dissections. One of the handles is attached

to a piece of wood, *b*; the other is curved as at *c*, in order to be pressed upon by the thumb or forefinger in the act of cutting.

The Microtome of M. Straus-Durekheim is constructed on a similar principle, but more simple in form. Its appearance is somewhat like the common shears, used for shearing sheep; the cutting blades being kept apart by their union in the handle, the distance being regulated by a screw and nut. By pressing with the fingers upon the Microtome it will close, and open when they are removed. The length of the cutting blades is 1¼ inch.

The ordinary scalpels or knives are usually too large for all purposes; those, however, which are used in operations on the eye will be of service.

For making fine sections, a scalpel or a razor may be employed, but for soft substances, as the liver, spleen, and kid-

Fig. 33.



ney, a knife with two parallel blades, called Valentin's Knife, Fig. 33, may be used with advantage. Dissecting needles may be straight or curved. One of the latter fixed in a pro-

Fig. 34.



per handle, is represented in Fig. 34. These are very serviceable instruments for separating or tearing asunder delicate tissues.

As most dissections are made under water, convenient troughs are necessary. They may be from two inches to a foot long and of a proportionate breadth and depth. Earthenware, or glass, is the best material. One may be prepared with a flat piece of cork cemented to the bottom, inside, by marine glue.

Loaded corks are flat pieces of cork with sheet lead cemented to their under surface with Burgundy pitch, so that they may readily sink in the water. To these corks the subject to be dissected is fastened with pins.

For vermiform animals, long, narrow, semicylindrical plates are best; to the convex surface of which they may be fastened, with the legs (if any, as in Myriopoda) hanging along the sides.

Rests are inclined planes of wood; one on each side of the trough holding the specimen. If the Dissecting Microscope, represented by Fig. 5, is used, neither rests nor troughs will be required, other than are furnished with the instrument; unless it be troughs for specimens not immediately under examination.

In addition to these instruments, a small syringe, camel's-hair pencil brushes, &c. &c., will be found useful.

For some objects, which are with difficulty kept in place for dissection, a little plaster may be mixed to the consistence of thin cream, and by means of a brush may be coated over those parts which are desirable to be fixed; then, by placing it in a small box or other suitable mould, the plaster may be poured round it, and allowed to harden. In this case a loaded cork is unnecessary, the weight of the plaster being generally sufficient. The plaster may be colored with ink, &c., if its whiteness is fatiguing to the eye.

Before dissection, a good light should be thrown upon the object by means of the condensing lens (Fig. 15).

A dissecting microscope is also generally necessary. This may be one specially designed for the purpose, as Fig. 5; or the

compound microscope with an erector, page 44; or a lens 2 or 3 inches focal length, or even smaller, fastened to a stem, so as to be adjustable over the object.

The following account of Swammerdam's dissections commends itself to all microscopists. It is condensed from an extract in Adams's Essays, from Boerhaave's Life of Swammerdam.

In the preparation of objects, no man was ever more successful or more indefatigable than Swammerdam. His chief art seems to have been in constructing very fine scissors, and giving them an extreme sharpness; these he made use of to cut very minute objects, because they dissected them equally, whereas knives and lancets, if ever so fine and sharp, are apt to disorder delicate substances. His knives, lancets, and styles, were so fine that he could not see to sharpen them without a magnifying glass.

He was also dexterous in the management of small glass tubes, which were no thicker than a bristle, and drawn to a fine point at one end, but thicker at the other. These he made use of to show and blow up the smallest vessels discoverable by the microscope; to trace, distinguish, and separate their courses and communications, or to inject them with subtile liquors.

He used to suffocate insects in spirits of wine or turpentine, and likewise preserved them some time in these liquids; by which means he kept the parts from decomposition, and added to them such strength and firmness as rendered the dissections more easy. When he had divided transversely the little creature he intended to examine, and carefully noted everything that appeared without further dissection, he then proceeded to extract the viscera in a very cautious and leisurely manner; first taking care to wash away and separate, with

fine pencils, the fat with which insects are plentifully supplied.

Sometimes he put into water the delicate viscera of the insects he had suffocated; and then shaking them gently, he procured himself an opportunity of examining them, especially the air-vessels and tracheæ, which by this means he could separate from all the other parts. Again, he has frequently made punctures in other insects with a needle, and after squeezing out all their moisture through the holes made in this manner, he filled them with air, by means of slender glass tubes, then dried them in the shade, and anointed them with oil of spike, by which means they retained their proper forms for a long time. He had a singular secret whereby he could preserve the nerves of insects as limber and perspicuous as ever they had been. Some insects he injected with wax instead of air.

He discovered that the fat of all insects was perfectly soluble in oil of turpentine; thus he was enabled to show the viscera plainly, only after this operation he used to cleanse and wash them well and often in water. He frequently spent whole days in thus cleansing a single caterpillar of its fat, in order to discover the true construction of this insect's heart.

His singular sagacity in stripping off the skin of caterpillars that were on the point of spinning their cones deserves notice. This he effected by letting them drop by their threads into scalding water, and suddenly withdrawing them; for by this means the epidermis peeled off very easily; and when this was done, he put them into distilled vinegar and spirit of wine, mixed together in equal proportions, which, by giving a proper firmness to the parts, afforded an opportunity of separating them, with very little trouble, from the exuviæ, or skins, without any danger to the parts; so that by this contrivance the

pupa could be shown to be wrapped up in the caterpillar, and the butterfly in the pupa.

Those who look into the works of Swammerdam, will be abundantly gratified, whether they consider his immense labor and unremitting ardor in these pursuits, or his wonderful devotion and piety. On one hand, his genius urged him to examine the miracles of the Great Creator in his natural productions; while, on the other, the love of that same All-perfect Being, rooted in his mind, struggled hard to persuade him that God alone, and not his creatures, was worthy of his researches, love, and attention.

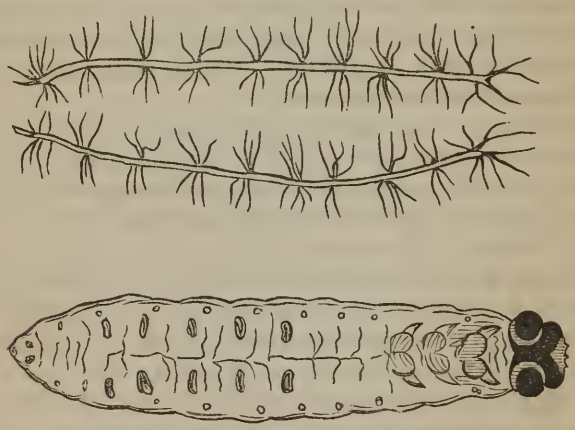
In addition to the chapter on procuring objects, a few further remarks on the internal anatomy of insects will not be out of place. For the microscopic anatomy of other parts of the animal organization, the reader is referred to Chapter V.

1. *Tracheæ*, or *Respiratory System of Insects.*—Respiration in insects is effected by means of two great longitudinal vessels or canals called tracheæ, running along the sides of the body beneath the outer integuments and muscles, terminating in breathing pores (spiracles or stigmata). These pores or spiracles are placed along each side of the body in terrestrial insects, and are furnished with a beautiful mechanism to prevent the admission of foreign particles. The tracheæ emit an infinite number of ramifications, extending to all parts of the body, so that air circulates freely in every part. The tracheæ consist of an elastic spiral cartilage rolled up into a tube, lined on each side with cellular tissue. In Fig. 35 the tracheæ of the larva of the *Cossus ligniperda*, or willow moth, is represented. Along each side of the caterpillar are seen the spiracles.

To obtain the tracheæ, &c., the insect should be placed in a small trough with water, and be securely fixed to a loaded cork. The body being laid open, next to the large viscera, the tra-

cheæ will become visible. These vessels, naturally filled with air, are of a beautiful metallic white color, which produces a very pretty effect upon the darker grounds of the other organs upon which they run. The stomach and intestinal canal, if large and transparent, will exhibit the minute ramifications of

Fig. 35.



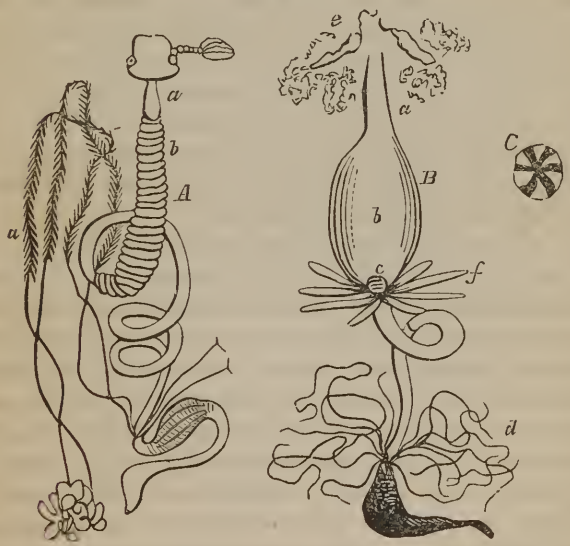
the trachęæ the best; for this purpose, after being slit open and well washed, they should be either mounted in fluid or be placed on a slide to dry. If care be taken in the mounting, they will show very well in balsam. When the entire tracheal system is required to be dissected from the larva of an insect, all the viscera should be taken out; the main trunks with their tufts of branches, will then be seen running down on either side of the body, and if care be taken in the dissection, the whole system may be removed from the cavity, and laid out, or rather floated on, a slide to dry, previous to being mounted in balsam. The spiracles require very little dissection. They

may be cut from the body with a scalpel or pair of scissors, and be mounted in fluid or in balsam.

2. *The Digestive System* consists of the pharynx; the œsophagus, or gullet; the craw, or crop; the gizzard, or ventriculus; the stomach, or duodenum; the intestines; and a number of slender membranous tubes, filled with a fluid analogous to bile. In addition to these, the salivary glands may be mentioned.

There is a very great variety in the digestive apparatus of insects. In those which feed on flesh, the alimentary canal is short, as in the higher animals, and in the vegetable eaters it

Fig. 36.



is long. There are also differences of structure which clearly show the adaptation of means to ends. A, Fig. 36, is the

digestive system of Melolontha. B, is that of Blatta Americana (American Cockroach), *a* is the œsophagus, *b* the crop, at the bottom of which is the gizzard, *c*, consisting of several teeth arranged like a funnel, with the apices of the teeth in the centre. Another view of the gizzard is seen at C. The bile-tubes or liver are shown at *d*, and the salivary glands at *e*. Attached to the stomach, just below the gizzard, are eight blind sacs, *f*, the use of which is unknown, but is supposed to be analogous to the pancreas.

The salivary glands, stomach, &c., should be generally mounted in fluid. Gizzards may be put up in balsam. The gizzard of a cricket is an interesting object; it has over two hundred teeth. They may be prepared by making a longitudinal incision and spreading out to dry; or by inflating, after the gizzard has been cleaned of its contents, by means of a small syringe. After drying in the latter mode it may be cut in two, so as to show the parts in their natural position.

The Nervous System consists of two medullary cords or threads, which run along the middle of the abdomen inside, exhibiting a series of knots or ganglia.

Fig. 37 exhibits the nervous system of a caterpillar, from a preparation of Dr. Goadby's. The double ganglion, A, seems to occupy the place of the cerebellum, and B, also double, and transverse to the others, answers to the cerebrum. C, C, the two cords uniting them. E, the space through which the œsophagus passes. F, F, F, the ganglia which unite the two cords. The distribution of the nerves through the body is from the ganglia. The apparent exception to this, as at D, are proven, by Dr. Goadby's investigations on the Limulus, to be, in fact, arteries, as they have been injected. Coagulated insect blood is white, hence they appear like nerves.

4. *The Circulatory System* is placed along the back, and consists of a heart or dorsal vessel; which is a tube divided

into chambers, separated from each other by valves. There are also valves at the sides to receive the blood from the venous sinuses of the body. But a single artery has been seen, which goes to the head, dividing into three branches. It was thought that the blood exuded through the vessel and found its way through the body as it best could, back to the heart; but in dissecting a Limulus (king crab), Dr. Goadby traced the artery into certain large sacs or vessels, evidently answering the purpose of veins (venous sinuses). It is probable the same holds

Fig. 37.

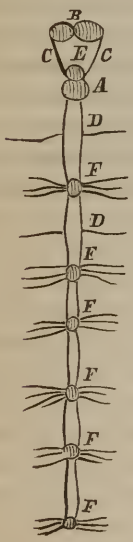
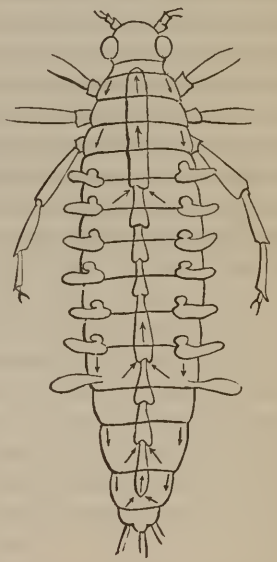


Fig. 38.



good of insects. Fig. 38 represents the dorsal vessel in the larva of Ephemera. The arrows indicate the current of the fluid.

In dissecting the heart or dorsal vessel, the body must be opened from the ventral surface, all the viscera removed, and the vessel left with its ligaments attached to the upper rings of the body. Or the superior segments of the body may be removed by cutting with scissors along the lateral membranous bands and removing all the upper part of the abdomen. The dorsal vessel may then be slit open. This dissection requires much care and great steadiness of hand.

5. The *muscular system* of insects is very extensive. Lyonet dissected and described 4061 in the caterpillar of the goat moth (*Cossus ligniperda*). M. Straus-Durekheim and others recommend that the insect should be cut in two a little to the right or left of the median line, so that the half to be examined shall be a little larger than the other, that the azygos muscles, &c., in the centre be not injured. Beginning then with the internal profile, layer after layer of muscles should be dissected.

By previous maceration in dilute alcohol the muscles are slightly hardened. If left too long, however, they will become detached from the integument.

CHAPTER IX.

THE CELL-DOCTRINE OF PHYSIOLOGY.

Reference has already been made at page 107 to the cause of vitality; alluding to it as a peculiar property impressed by the Creator on all organized structure,—a property altogether distinct from Volition and Sensation, which exclusively belong to animals, and which point out the existence of a special entity, or being, resident in the organism, but whose properties cannot properly be referred either to matter or its organization.

Respecting the essential nature of the vital principle, much speculation has been uselessly employed. Some have confounded it with the entity, or being, in the animal, which *perceives* and *wills*. But this is manifestly an error, inasmuch as it pertains also to vegetables. Very many parts of the organization, also, have an independent vitality (without special sensibility), separate from that of other parts, as we shall see in the progress of this chapter. It seems, therefore, most reasonable to define it as a peculiar property of organization; as gravitation, electricity, &c., are special properties of matter under other circumstances, the essential nature of which are just as mysterious as that of Life.

Mysterious as this subject is, it is nevertheless interesting to trace the origin and development of organized structures; and the progress of modern science has supplied us with the means of instruction. Chemistry teaches us that the ultimate elements

of organized bodies are identical with the elements of other bodies; and the microscope detects the earliest forms produced by the vital process, and the part sustained by them in the development of each species.

Chemical analysis shows, that what are termed *simple elements*, as oxygen, hydrogen, carbon, nitrogen, sulphur, &c., are peculiarly arranged in all organized bodies; having special affinities which they do not possess in unorganized substances, or bodies destitute of life. These peculiar affinities form a class of compound substances called *proximate principles*, or *organic compounds*, or *organizable substances*. They are obtained by the analysis of organized textures: such are *albumen*, *fibrin*, *starch*, *gluten*, &c.

Owing to the feeble affinity of the simple elements in the organic compounds, there is a great tendency in them to enter into new combinations, forming what are called *secondary organic compounds*. Such are *urea*, *uric acid*, *pepsine*, *sugar of milk*, &c.

Hitherto, no one has succeeded in producing the true proximate principles by chemical synthesis, and it is doubtful if they will ever be produced elsewhere than in the living organism. Some of the secondary organic compounds have, however, been formed in the laboratory of the chemist; as the production of urea from cyanate of ammonia through the action of heat, which has been effected by Wöhler.

"The simplest and most elementary organic form with which we are acquainted, is that of a cell, containing another within it (*nucleus*), which again contains a granular body (*nucleolus*)." See Fig. 39.

"This appears, from the interesting researches of Schleiden and Schwann, to be the primary form which organic matter takes when it passes from the condition of a proximate

principle to that of an organized structure." (*Todd and Bowman.*)

There are some animal tissues, however, which seem to have a lower grade of organization than cells, being apparently

Fig. 39.



produced by the simple solidification of the plastic or organizable fluid: this fluid is, however, prepared by cells, and is set free by their rupture. This seems to be the case with the delicate membrane known as the *Basement* or *Primary Membrane*, beneath the epidermis or epithelium. According to Dr. Carpenter, in many specimens of this membrane, no vestige of cell-structure can be seen, and it resembles that of which the walls of the cell are themselves constituted. In other cases it presents a granular appearance under the microscope, and is then supposed by Henlè to consist of the coalesced nuclei of cells, whose development has been arrested. Other specimens of basement membrane, however, described by Goodsir, present a distinctly cellular structure, the cells being polygonal, and each having its own granular nucleus.

Cells are formed in two ways; either in a previously existing, structureless fluid called a *blastema*, or within the interior of previously existing cells. In the first method, the plastic fluid becomes opalescent from the deposition of a number of *nucleoli*; several of these become aggregated, and form the *nucleus*, within which the nucleolus can still be seen. This nucleus is called the *cytoblast* (from κυτος, a vesicle, and βλαστος, a germ), or *cell-germ*. From the side of this nucleus a thin transparent membrane projects, like a watch crystal from the dial, and

gradually enlarges till at last the nucleus is seen only as a spot on its wall. The whole is then called a *nucleated cell*, or *germinal cell*. The fluid in which the granules are first deposited is called the *cytoblastema*.

In the second method of development, each granule of the nucleus has the power of developing a cell, so that the parent cell becomes filled with one or more generations of new cells, which may either disappear entirely, or by the rupture of the original cells the contents may be scattered, and undergo an independent development.

Sometimes several nucleoli are seen within one nucleus, and several nuclei within one cell.

Each cell is an independent organ, living for itself, and by itself, and depending upon nothing but a proper supply of nutriment, and of the appropriate stimuli for the continuance of its growth and for the performance of its functions, until its term of life is expired.

The development of cells goes on at every period during the life of the organism. They are found floating in immense numbers in the blood, chyle, and lymph; and even in diseased secretions, as pus. In the inflammatory process they are produced in great quantities; and the malignant growths, such as cancer and fungus hæmatodes, which infest the body, are owing to the same agencies. In short, the nucleated cell is the agent of most of the organic processes, both in the plant and animal, from the dawn of their existence to their full maturation and decline.

The forms of cells are various (see Fig. 24); some being spheroidal, others cubical, prismatic, polygonal, or cylindrical. They are subject also to various transformations. Sometimes a number of cylindrical cells are laid end to end, and by the absorption of the transverse partitions form a continuous tube; as in the sap vessels of plants, muscular and nervous fibre, &c.,

At other times the cells are elongated and fusiform, as in woody fibre; or they may send forth prolongations, assuming a stellate or irregular appearance, as in the pigment cells of the Batrachia, and Fishes, or some of the vesicles in the gray matter of the nervous system. Further, the original boundaries of the cells may be altogether lost, from their coalescence with each other; or their cavities be so occupied by internal deposits that they may be mistaken for solid fibres.

The nuclei are also subject to change of form. In some instances we find it sending out radiating prolongations, so that it assumes a stellate form, like that of the cells of the Gera-

Fig. 40.



nium-petal, Fig. 40; this seems also to be the case with the nuclei of the bone cells. In vegetables, the wall of the cell always remains, while in bone it disappears, and the canaliculi anastomose. In other cases it seems to resolve itself into a fasciculus of fibres; and this Henlé conceives to be the origin of the yellow fibrous tissue. Further, it may separate into a number of distinct fibres, each composed of a linear aggregation of granules; in this manner, the dental tubuli appear

to be formed. Lastly, Dr. Carpenter thinks it may disperse itself still more completely into its component granules; by the reunion of which certain peculiar vibrating filaments (the so-called spermatozoa) may be formed.

"In the lowest and simplest forms of living beings," says Dr. Carpenter, "such as we meet with among the humblest cellular plants, we find a single cell making up the whole fabric. This cell grows from its germ, absorbs and assimilates nutriment, converts a part of this into the substance of its own cell-wall, secretes another portion into its cavity, and produces from a third the reproductive germs that are to continue the race; and having reached its own term of life, and completed the preparation of these germs, it bursts and sets them free—every one of these being capable, in its turn, of going through the same set of operations. In the highest forms of vegetable life, we find but a multiplication of similar cells; amongst which these operations are distributed, as it were, by a division of labor; so that, by the concurrent labors of all, a more complete and permanent effect may be produced."

Of the development of animal tissues, Todd and Bowman present the following interesting account, in their "Physiological Anatomy and Physiology of Man."

"The prevailing mode in which the development of animals takes place, is by the formation, within the parent, of a body containing the rudiments of the future being, as well as a store of nutrient material sufficient to nourish the embryo for a longer or shorter period. This body is called the *ovum* or egg. It is of that form which, in a former page (see Fig. 39, page 131), has been described and delineated as the simplest which organization produces. It consists of a vesicular body filled by a fluid, and enclosing another, within which is a third, consisting of one or more minute, but clear and distinct granules. The first or *vitelline* membrane of the ovum, is the wall of a cell; it is composed of homogeneous membrane: the second,

or the *germinal vesicle* of the egg, is the nucleus of the first; and the third, which is called by embryologists the *germinal spot*, is a nucleolus to the second. It appears from the researches of Wagner and Barry, that the nucleus or germinal vesicle precedes the formation of the vitelline membrane, but the precise relation, as to the period of its formation, of the nucleolus or germinal spot to the nucleus, has not yet been satisfactorily made out. The germinal vesicle and spot become the seat of a series of changes, which give rise to the development of new cells, for the formation of the embryo.

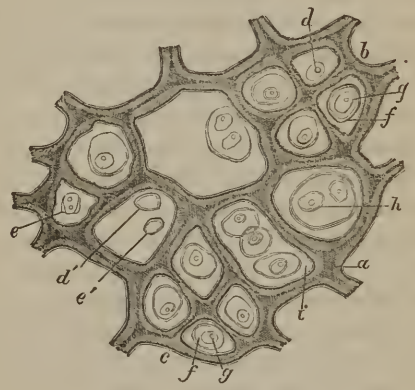
"At this period the embryo consists of an aggregate of cells, and its further growth takes place by the development of new ones. This may be accomplished in two ways: first, by the development of new cells within the old, through the subdivision of the nucleus into two or more segments, and the formation of a cell around each, which then becomes the nucleus of a new cell, and may in its turn be the parent of other nuclei: and secondly, by the formation of a granular deposit between the cells, in which the development of the new cells take place. The granules cohere to each other in separate groups here and there, to form nuclei, and around each of these a delicate membrane is formed, which is the cell-membrane.

"In every part of the embryo the formation of nuclei and of cells goes on in one or both of the ways above mentioned; and by and by, ulterior changes take place, for the production of the elementary parts of the tissues."

The mode of development just referred to may be illustrated by the following cuts. Fig. 41 exhibits a section of one of the branchial cartilages of the young tadpole. Within the large parent-cells, that are held together by intercellular substance, *a*, *b*, *c*, we observe secondary cells in various stages of development: at *d*, the nucleus is single; at *e*, it is dividing into two; in the adjoining cell, the division into two nuclei *d'* and *e'*, is complete; at *h*, two such nuclei are enclosed within

a common cell-membrane; at *i*, we see three new cells (one of them elongated, and probably about to subdivide) within the parent; and in each of the two groups at the top and bottom

Fig. 41.



of the figure, we have four cells, separated by partitions of intercellular substance, but having manifestly originated from one parent cell.

Fig. 42 represents endogenous cell-growth in cells of a meliceritous tumor; *a*, cells presenting nuclei in various stages of development into a new generation; *b*, parent-cell, filled with a new generation of young cells, which have originated from the granules of the nucleus.

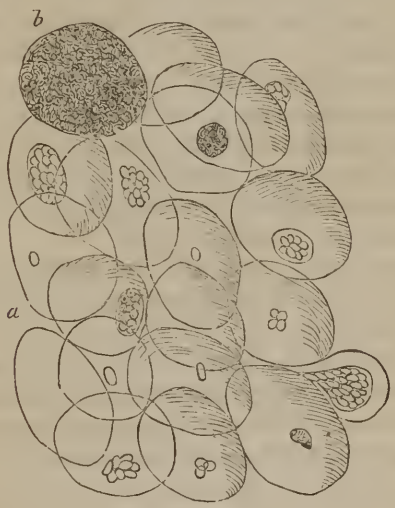
The following arrangement of animal tissues is based upon that adopted by Dr. Carpenter.

1. Simple membrane; homogeneous, or nearly so, employed alone, or in the formation of compound membranes. Its principal character in extension, but its ultimate structure defies the highest powers of the microscope.—Examples are seen

in the posterior layer of the cornea, capsule of the lens, sarcolemma of muscle, &c.

2. Simple fibrous tissues, including the white and yellow fibrous tissues, and the areolar tissue, which is formed from

Fig. 42.



them. Henlé believes the white fibrous tissue to be formed by cells; the yellow, by nuclei.

3. Simple cells, floating separately and freely in the fluids, as corpuscles of the blood, lymph, and chyle.

4. Simple cells developed on the free surfaces of the body, as epidermis and epithelium.

5. Compound membranes; composed of simple membrane, and a layer of cells, of various forms (epithelium and epidermis); or of areolar tissue and epithelium; as mucous membrane, skin, secreting glands, serous and synovial membranes.

6. Simple isolated cells, forming solid tissues by their aggregation; as fat cells, the vesicles of gray nervous matter, absorbed cells of the villi, and the cellular parenchyma of the spleen. In these cases the cells are held together by the blood-vessels and areolar tissue, which pass in between them; in cartilage, and other tissues allied to it in structure, the cells are united by intercellular substance, either homogeneous, or of a fibrous character.

7. Sclerous or hard tissues, in which the cells have been more or less consolidated by internal deposit, and more or less completely coalesced with each other; as the hair, nails, &c. These instances may be more properly ranked under the epidermic tissues; the result of consolidated deposit is more characteristically seen in bones and teeth.

8. Tubular tissues; formed by the coalescence of the cavities of cells; as in the capillary blood-vessels, muscular fibre, tubuli of nerves, &c.

In some of these, as muscle and nerve, a deposit has taken place subsequently to the coalescence of the original cells.

To these we may add,—9. Compound tissue; formed of areolar tissue and cartilage; as fibro-cartilage.

CHAPTER X.

EXAMINATION OF MORBID STRUCTURES, ETC.

For the purpose of making a microscopic analysis of abnormal or other fluids, certain chemicals will be required; as liquor potassæ, ammonia, ether, and alcohol, acetic, nitric, hydrochloric and sulphuric acids; together with a few test-tubes and watch-glasses.

In the case of solids, the various kinds of scalpels, dissecting needles, and Valentin's knife, will be useful.

If the subject for examination be fluid, as blood, pus, mucus, &c., a very small quantity should be put on a clean slide, and covered with a piece of thin glass. A fishing-tube (page 49) will be of service for this purpose.

If there be sediment in the fluid, it should be allowed to subside, when it can be transferred by the fishing-tube to the slide. A small quantity of any reagent which may be desired, may be brought in contact with one of the sides of the thin glass cover, when it will gradually insinuate itself between the glasses, and act slowly on what is contained there. In other cases, the cover may be lifted up, and the reagent added.

In the case of blood, the fluids that require to be added are generally, ordinary water; serum; and sugar or salt, dissolved in water; but in the case of pus and mucus, which approach each other so nearly in many of their characters, it becomes of importance to have some test whereby they may be distinguished

from each other. The fluid employed for this purpose is acetic acid. When this is added to a fluid where pus is present, the globules swell up, and several large, transparent nuclei make their appearance; but when it is added to a fluid where mucus is present, the globules also enlarge and show their nuclei, but not so plainly as the pus, and the liquid, termed liquor mucí, in which the globules float, is instantly coagulated into a semi-opaque corrugated membrane.

The presence of fatty matter is ascertained by sulphuric ether, which readily dissolves the oily part, and leaves the membranous cell-wall untouched.

Earthy matters require the aid of the acids for their solution; these should be added in a dilute form, so that their solvent action may be more easily witnessed.

Solid parts, as tumors, &c., that are to be examined as transparent objects, with high powers, require to be cut into very thin slices, and separated, if necessary, by the needle-points. The sections should be placed on a slide, and a little serum or white of egg in water, added, in order to float out certain of the parts, and to lessen the refraction of the light at the edges of the object. Water will answer the purpose for some of the hard tissues, but where nucleated or other cells, and nervous matter, are present, its use is inadmissible.

It is necessary to state, that the examination of all morbid structures should be made as soon as convenient after their removal from the body, as changes of form in the softer substances speedily take place; but if some time has elapsed, the part from which the sections are taken should be at some distance from the surface, in order that they may be as little altered as possible by the action of the air.

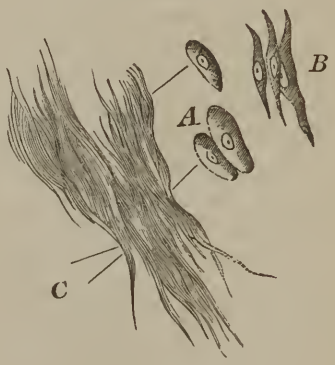
The foregoing directions have been condensed from those of Mr. Quekett, to whose book we have already been much indebted during the progress of this work.

It was at one time "fondly hoped" (says Dr. McClellan), "that by the aid of powerful microscopes we could be able to detect the pre-existing germs of all organic diseases in the general circulation, and decide not only as to the species of affection, but also concerning the degree of constitutional contamination. It was even thought that cancers could thus be distinguished from scrofula and all other more innocent diseases; while, at the same time, we could form a conclusive opinion as to the propriety of attempting or declining a surgical operation, or of instituting any mode of local treatment for the purpose of affording relief. But all such attempts have proved to be illusory, and we can gather no other practical knowledge from the use of the microscope than what is connected with the minute anatomy of the morbid structures after they have been elaborated." With all deference to the opinion of so truly a great mind as the lamented McClellan, we may be permitted to remark, that notwithstanding much has been done by the labors of European and other observers, minute pathological observation is still in its infancy; yet it has made a deep impression upon the study of medical science. When "the minute anatomy of the morbid structures" shall be fully known, our knowledge of organic diseases will have advanced to a great degree of perfection. Dr. McClellan is not himself insensible of the advantages to be derived from microscopic investigations, although we think he places too little value upon them. He says, "Chemical analyses and microscopic researches have lately proved that a great number of cases (of tumors) which were once thought to be scirrhous, or cartilaginous, or osteo-sarcomatous, are really composed of condensed fibrine of the blood, sometimes partially altered into albumen or gelatin."

The microscopic appearance of a fibrous tumor is exhibited in Fig. 43 (after Vogel). It shows interlacing fibres, C. Pri-

mary cells with nuclei and nucleoli, A, and the same cells elongated and becoming caudate, B. The interlacing fibres appear to be identical with the fibres of coagulated lymph.

Fig. 43.



Malignant growths may be divided into three classes of disease. 1. Scrofula, and its varieties. 2. Carcinoma, or scirrho-cancer. 3. Encephaloid disease, or medullary fungus.

1. Scrofulous growths present three forms of manifestation. In the lymphatic ganglia and in the conglomerate glands; in well-defined spherical tubercles, which appear first as small points or grayish granules; and depositions which appear during the progress of typhus fever, between the muscular and mucous coats of the intestines, in the mesenteric glands, in and under the mucous membrane of the trachea, and sometimes in the substance of the lungs and spleen. Fig. 44 shows the microscopic appearance of typhous matter from the mesenteric glands. A, an amorphous, slightly granular mass, of a brownish-white color, with an immense number of cells deposited; B, the amorphous mass treated with acetic acid, by which

it was rendered transparent, and gradually dissolved, upon which many minute cells with a sharp outline came into view, being unaffected by the acid (Vogel).

Fig. 44.



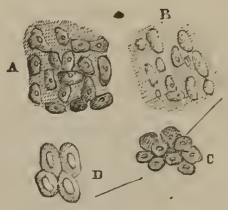
There seems no distinction between tuberculous matter and that of scrofula or typhus. Fig. 45 exhibits tubercles in various stages of development. A, B, C, tubercles from the lungs of a young man who died of tuberculosis pulmonum.

A, B, nuclei in an amorphous cytoblastema; most of the nuclei contain nucleoli. At C the cytoblastema has disappeared and the cells are in contact. D, tubercular cells, from the lungs of another young man. Here the cytoblastema has also disappeared, and the nuclei are enclosed in a cell-wall; no nucleoli are present.

2. Carcinoma. In cases of true scirrhus, the matrix or stroma is constituted either by a new development of cellular

texture, or by an induration and enlargement of the original areolar tissue of the part. The larger and coarser fibres and

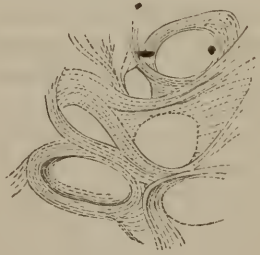
Fig. 45.



lamellæ of this tissue become converted into dense and firm ligamentous bands, which intersect each other in various directions.

Vogel, and some other writers, describe a second kind of fibres, which occur in a reticulated form, cross-barred, or in irregular meshes. They are distinguished from the first-mentioned whitish or ligamentous bands, by being insoluble in acetic acid. Fig. 46 (from Vogel, after Müller), shows the

Fig. 46.



fibrous stroma of scirrhus, as seen in the microscope. The meshes are formed by bundles of carcinoma reticulare of the breast, as they appear after the globules have been removed.

The dense, firm, bluish-white, or yellowish and amorphous-looking substance which fills the interstices of the stroma is rendered transparent by acetic acid, and by ammonia and other caustic alkalies. This, though deposited in a fluid state, acquires its solidity by coagulation, after which it is thought that the peculiar cancer cells, or fibres, which constitute the malignant character of the disease, are developed.

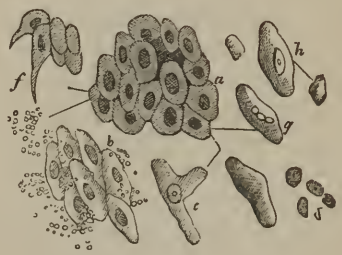
The principal forms of cells which enter into the composition of cancerous growths are—1. The irregularly caudate or ramifying cells; 2. Larger cells filled with nuclei; and 3. Granular cells filled and covered with granules. Besides these, Vogel describes cells with a thick wall, exhibiting a double contour; double cells formed by the division of one or the fusion of two cells; and pigment cells, enclosing dark, granular pigment.

The above are transitory or effete cells. The persistent or fibre cells are fusiform, such as occur in the development of areolar tissue, and of simple muscular fibre. They occur in the firm, rarely in the soft forms of cancer, and seem destined for the formation of the areolar tissue, and the intersecting ligamentous bands. In addition to all these, there appear numerous particles or granules of broken-down lymph and fat; large fat granules and globules; and a viscid, gelatinous fluid. These latter, however, may be considered adventitious and not essential formations.

The microscopic appearance of scirrhus (220 diameters) is exhibited in Fig. 47. Small masses that had been pared from a recent section of the tumor, and moistened in water, consisted entirely of an accumulation of cells. These were very pale, varying in size and form, being sometimes roundish, *a*, sometimes oval, *b*, or caudate, *f*, or again of irregular form. The greater number exhibited nuclei, *a*, *b*, and in some a nucleolus was visible in the nucleus, *c*, *h*; few were devoid of

nuclei; on some, fat globules were observed, *g*. Between these cells were perceived nuclei with or without nucleoli, *d*. (Vogel.)

Fig. 47.



3. Encephaloid disease or fungoid tumor, differs from scirrhous cancer chiefly in the great predominance of its transitory or morbidly developed cells over the fibrous and other elementary textures which constitute the stroma (matrix) of the tumor. In carcinomas, the fibrous tissue predominates and gives solidity and firmness to the whole mass. The morbid or cancer cells never tend to develope organized fabrics, but always to disintegration and softening down of the tumor. Their great predominance in encephaloid, therefore, gives the character of brain-like softness and yielding, which is the distinguishing characteristic of this form of malignant growth.

Fig. 48 represents encephaloid, from the liver, under the microscope. It appeared wholly composed of cells, which showed distinct nuclei and nucleoli. The cells were mostly roundish or oval, but some were caudate. Acetic acid rendered them full and brought the nuclei plainly in view, *a*. Here and there some nuclei were seen in an amorphous cytoblastema.

Although the cells of encephaloid belong to the class of

effete or transitory cells which also occur in cancer, yet there is a difference in the proportions of various kinds of these cells

Fig. 48.



in the two classes of tumors. The predominating cells of this kind in fungoid tumor are the very large parent cells, with numerous young cells or cytoblasts in their interior. They are often as large as $\frac{1}{30}$th of a line in diameter; and the caudate cells are always irregularly caudate or ramifying.

There are seldom any of the regular caudate or elongated cells of small size, such as go to the formation of the cellular and fibrous tissue, and of true cancers. The fat cells and

Fig. 49.



granules are perhaps more abundant than in scirrhus. Fig. 49 is the microscopic appearance of encephaloid, consisting of

cells of different size and form; round, oval, and caudate, but no one form predominating over the rest. Some are very large, *a*, enclosing several minute cells with nuclei. Isolated cells, although in a proportionately small number, contained dark granules, *b*. For further observations on microscopic pathology, the reader is referred to Vogel's Pathological Anatomy, and other similar works.

The Monthly Journal of Medical Science for May, 1847, contained an account of a new instrument for the diagnosis of tumors. It was presented to the Medical Society of Strasbourg, by M. Kün, Professor of Physiology in that city.

"It consists in an exploring needle, having at its extremity a small depression with cutting edges. On plunging this instrument into a tumor to any depth, we can extract a minute portion of the tissue of which its various layers are composed. In this manner a microscopic examination of the tumor can be practised on the living subject, and its nature ascertained before having recourse to an operation."

With respect to the Morphology of various pathological fluids, a great deal has been effected by microscopic investigation. In the Microscopic Journal, vol. ii., is a series of essays on this subject, by Dr. David Gruby, translated from the Latin by S. J. Goodfellow, M.D., which are worthy of careful perusal and experimental verification. The results of Dr. Gruby's researches are appended.

RESULTS OF DR. GRUBY'S OBSERVATIONS ON PATHOLOGICAL MORPHOLOGY.

TRANSLATED BY S. J. GOODFELLOW, M.D.

A. OF MUCUS.

Healthy mucus and mucus generated by irritation and normal inflammation, are composed of an amorphous ductile substance (proper mucus), globules, and epithelium.

Healthy Mucus.	Mucus produced by normal Irritation.	Mucus produced by slight normal Inflammation.	Mucus produced by a more intense normal Inflammation.	Mucus produced from chronic normal Inflammation.
Very few globules	Very few globules	Globules more numerous	Globules very numerous	Globules very abundant
Much of an amorphous substance (proper mucus)	Very much of proper mucus	Less mucus	Much less mucus	Very little mucus
Contains but little epithelium	Contains but little of epithelium	Contains more epithelium	Contains very little epithelium	Contains very little epithelium
Globules from 2–4 times larger than the blood particles	Globules from 4–5 times larger than the blood particles	Globules 6–8 times larger than the blood particles	Globules from 6–8 times larger than the blood particles	Globules 6-8 times larger than the blood particles
No molecules, or the smallest, fill the globules	The smallest molecules fill the globules	The smallest molecules (filled with), and a central vesicle	Filled with the smallest molecules and a central vesicle	Filled with the smallest molecules and a central vesicle
Very thin envelope to the globules	Very thin smooth envelope	Smooth envelope	Smooth envelope	Smooth or no envelope
Not changed in water	Globules swell in distilled water	Swelled in distilled water	Globules swell in distilled water	Swell in distilled water
		Envelopes easily broken in water	Envelopes easily broken	Envelopes easily broken

MUCUS PRODUCED FROM SPECIFIC OR ANOMALOUS INFLAMMATION CONTAINS, BESIDES SUBSTANCES PECULIAR TO NORMAL MUCUS, OTHER FORMS.

Mucus generated from tuberculous inflammation of the lungs.	Dysenteric mucus.	Mucus of urethral blennorrhœa.
Besides the products of catarrhal inflammation contains yellow lenticular spheres 1–8 times larger than the globules of pus, concentrically striated, composed of concentric lamellæ, which are dissolved in caustic potash	Contains globules with central vesicles and molecules, round or ovate greenish corpuscles endowed with the smallest molecules, symmetrically disposed, and also products of catarrhal inflammation	Contains from the beginning a very few globules exceeding four times the diameter of the particles of the blood, and provided with the smallest molecules and an envelope
In nitric acid—solution of nitrate of silver { They are increased 5 times in volume and become transparent		On the third day it is composed of many globules, the smallest molecules, an envelope, and central vesicle
Some pulmonal cells and muscular fibres are seen in it		On the tenth day *all* the vesicles are endowed with central vesicles
		They swell and are easily broken in water
		On the fortieth day very few globules are found

B. OF PUS.

Pus is composed of a certain white pellucid fluid and globules; sometimes other substances are mixed with these.

PUS GENERATED BY NORMAL INFLAMMATION.

Pus from a recent Wound.	Pus from a recent Abscess.	Pus from an old Abscess.	Pus from an old Wound.	Pus from the surface of an organ whose continuity is uninjured.
Few globules	Many globules	Many globules	Fewer globules	Fewer globules
Contains more fluid	Contains but little fluid	Contains but little fluid	But little fluid	Much fluid
Globules from 4–6 times larger than those of the blood	Globules 3–4 times larger than those of the blood	Globules 3–4 times larger than those of the blood	Globules 3–4 times larger than those of the blood	Globules 6–8 times larger than those of the blood
			Contains a good deal of epithelium	Contains but little epithelium
With very small and larger molecules	With very small and larger molecules	With very small and larger molecules	With very small and larger molecules	With very small and larger molecules or none
Have one central vesicle and an envelope	One or two central vesicles, seldom without one	With a central vesicle	No central vesicle	Composed of a central vesicle full of molecules, or none at all in it
Globules swell, and envelope bursts in distilled water	Globules swell, and envelope broken in distilled water	Swell but little in distilled water	Does not swell in distilled water	Sometimes swell in distilled water

1. Generated during the Variolous Process.			2. Generated in the Tubercuous Process.
A. During the formation of papulæ.	B. During the formation of vesicles.	C. During the formation of pustules.	
The pellucid fluid extricated offers an alkaline reaction. Is composed of a white pellucid fluid and a few free molecules of the larger and smallest kind, and animalcules On the third day after the eruption larger molecules and a few white almost pellucid globules 2–3 times larger than those of the blood Filled with the smallest molecules Molecular motion scarcely to be seen Animalculæ are found in it	On the 4th day a little limpid serum Contains globules endowed with the smallest and larger molecules, and a central vesicle The envelopes are not easily broken Vehement molecular motion Animalcules, and free very small globules On the 5th day the turbid serum has an alkaline reaction Contains globules of the larger yellow molecules The envelopes are easily broken The molecular motion and animalcules are well seen	On the 6th day the thicker yellow fluid has but a slight alkaline reaction The globules 4 times larger than those of the blood, many with an envelope easily to be broken or without one Filled with the smallest or the larger molecules, and sometimes provided with a central vesicle The molecular motion diminished On the 7th day and beyond, the yellow thick fluid contains many globules adhering together The envelopes are very easily broken, the molecules dissipated without order Cells of epithelium and drops of fat are frequently seen in it	See—Mucus produced from Specific Inflammation.

N.B.—In some individuals the globules are 3–4 times larger than those of the blood, perfectly or partly empty, also spheres twice or six times larger than the pus globules, consisting of smaller spherules.

C. OF SEROUS EXUDATION.

WHITE, OR GREENISH-WHITE, LIMPID, EXUDATED, SEROUS FLUID IS COMPOSED OF A PELLUCID FLUID AND GLOBULES.

SEROUS EXUDATION OF A BLADDER PRODUCED BY BLISTER.	SEROUS EXUDATION FROM CRUDE INFILTRATION OF INTESTINAL TYPHUS.	SEROUS EXUDATION EXTRACTED FROM THE PAPULÆ OF MODIFIED VARIOLA.	SEROUS EXUDATION EXTRACTED FROM THE FIBRINE OF A VILOUS HEART.	SEROUS EXUDATION FROM A HYDROCYST.	SEROUS EXUDATION FROM ŒDEMA OF THE CUTIS.	SEROUS EXUDATION EXTRACTED FROM THE SUBSTANCE OF AN INFLAMED HUMAN PLACENTA.	SEROUS EXUDATION FROM THE VAGINAL DISCHARGE IN THE THIRD PERIOD OF PREGNANCY.
Contains white globules with a very thin covering filled with the smallest molecules, or destitute of all covering 1-2 larger than the blood globules	Contains white globules with an envelope filled with the smallest molecules. 1-2 larger than the blood globules	Contains white globules with a very thin covering filled with the smallest molecules 1-4 times larger than the blood globules	Contains white globules, consisting of a very thin envelope, filled with the smallest molecules 1-2 times larger than those of the blood	Contains perfectly round white globules destitute of molecules. Scarcely larger than the globules of the blood	Contains white or yellowish-white stellated globules, scarcely larger than those of the blood Here and there provided with a small nucleus	Contains white globules, with an envelope filled with the smallest molecules 1-2 times larger than those of the blood	Contains white globules, with an envelope filled with the smallest molecules Once to twice larger than the blood discs

D. THE MORPHOLOGY OF THE GLOBULES GENERATED DURING THE PATHOLOGICAL PROCESS.

1. THOSE WHICH OCCUR IN MUCOUS MEMBRANE.

IN HEALTHY MUCOUS MEMBRANE.	IN IRRITATED MUCOUS MEMBRANE.	IN SLIGHTLY IRRITATED MUCOUS MEMBRANE.	IN A MORE INTENSE INFLAMMATION OF MUCOUS MEMBRANE.	IN CHRONIC INFLAMMATION OF A MUCOUS MEMBRANE.
Very few yellowish-white globules are generated provided with a covering, and enclosing none or very few of the smaller molecules They are not changed in water, and are from 2-4 times larger than those of the blood	Very few yellowish-white globules are generated They are provided with an envelope, enclosing the smallest molecules, and are 4 times larger, than the blood globules, and swell in water	More copious or abundant yellowish-white globules are generated. They are provided with an envelope, filled with the smallest molecules and a central vesicle, and swell, and are broken in water. They are 8 times larger than the blood globules	The yellow globules are generated in greater abundance, 8 times larger than the blood globules, endowed with an envelope, filled with the smallest molecules, and a central vesicle They swell, and are broken, in water	The yellow globules are generated in the greatest abundance, are 8 times larger than the blood globules, endowed with an envelope, or an envelope with the smallest molecules, and a central vesicle

2. THOSE WHICH ARE GENERATED IN THE SKIN.

By the application of a blister.	By the variolous process under the formation of papulæ.	By the variolous process during the formation of vesicles.	By the variolous process during the formation of pustules.	By the variolous process during the formation of crusts.
A very few white globules, 2–3 times larger than the blood globules, endowed with no envelope, or one filled with the smallest molecules Water does not change them	A very few white globules, 2–3 times larger than those of the blood, pellucid, endowed with a very thin covering, enclosing the smallest molecules They swell in water	Numerous yellowish-white globules, 3–4 times larger than those of the blood, endowed with an envelope, filled with the smallest and larger molecules, and a central vesicle They swell, and are broken, in the water	Very numerous yellow globules, 4–5 times larger than those of the blood, provided with the smallest and larger molecules, and the central vesicle They swell in water, and are easily broken	A few yellow whole globules, 4–5 times larger than those of the blood: many lacerated, furnished with no envelope, or with one filled with the different molecules. They are easily broken.

3. THOSE WHICH ARE GENERATED IN SEROUS MEMBRANE.

Hydrocysts.	Of the pericardium under the formation of the villous heart.	Of an inflamed peritoneum.	Of an inflamed peritoneum neonati.	Of a very acutely inflamed peritoneum.
White, pellucid, perfectly round globules are formed scarcely larger than those of the blood, with an envelope destitute of all molecules They are not changed in water	White globules, 2–3 times larger than those of the blood, endowed with a very thin envelope, filled with the smallest molecules They swell in water	Yellowish-white globules, 3–6 times larger than those of the blood, formed with an envelope, filled with the smallest and larger molecules They swell in water	Yellowish-white globules, 4–8 times larger than those of the blood, composed of a very fine envelope, with a few very small molecules or none, and with a central vesicle, either filled with the smallest molecules, or possessing none They are not changed by water	Yellow globules, 4–8 times larger than those of the blood, either with a very thin envelope partly or entirely filled with the smallest or larger molecules, or with no envelope They are not changed by water

THOSE WHICH ARE GENERATED IN PATHOLOGICAL (DISEASED) PARENCHYMA.

Of crude, recent infiltration of the ileum.	Of the red infiltrated mesenteric glands in abdominal typhus.	In the process of purulent infiltration of the cellular tissue.	In the softened mesenteric glands in abdominal typhus.
The globules are white diaphanous, scarcely exceeding the diameter of the blood globules, with a smooth envelope filled with the smallest molecules They swell but little in water	Yellowish-white diaphanous globules exceeding from 2-4 the globules of the blood, composed of an envelope filled with the smallest molecules, or 6 times larger than those of the blood, with an envelope filled with the smallest molecules and a central vesicle, of many molecules	Round yellowish-white globules, exceeding 4 times the magnitude of those of the blood, composed of an envelope filled with the smallest molecules They swell but little in water	Round yellowish-white globules 4-8 times larger than those of the blood, composed of an envelope with the smallest or larger molecules They swell in water

Of a hepatized recent placenta.		In the exudation of plastic lymph in croup.	
White globules scarcely exceed those of the blood, composed of an envelope, filled with the smallest molecules		Round yellowish white globules exceeding 3 or 4 times the size of those of the blood, composed of an envelope filled with very small molecules They are not changed by water	

Of a hepatized spleen.
White globules equalling in magnitude the globules of the blood, or twice as large, with or without an envelope, but if with one it is filled with the smallest molecules They are not changed by water

THOSE WHICH ARE GENERATED ON THE SURFACE OF A PATHOLOGICAL (DISEASED) ORGAN.

EXPOSED.

In the tenth hour of a recent wound.	Of pus of a recent wound 24 hours and beyond.	Of pus in the seventh week of a recent wound.	From an old wound suppurating but little.
A few round, white, transparent globules 1–3 times larger than those of the blood, composed of a very thin envelope filled with the smallest molecules They swell but little in water	Round yellowish-white abundant globules 4–6 times larger than those of the blood, endowed with a very thin envelope with the smallest and the larger molecules, and also a central vesicle They swell in water	Very numerous round yellowish globules 5–8 times larger than those of the blood composed of an envelope with the smallest molecules and a central vesicle They swell and their envelopes are broken in water	A few yellow roundish globules 2–4 times larger than those of the blood, composed of a dense envelope full of the smallest molecules They are not changed by water

SHUT.

Of a recent idiopathic abscess of the abdomen.	Of idiopathic abscess of the liver.	Of an old idiopathic abscess.	Of a metastatic abscess of six days' standing.
Round or oblong yellow globules 4–6 times larger than those of the blood, composed of a very thin envelope, with the very small and larger molecules, either with or without a central vesicle, or a simple or double one They swell in water and their envelopes burst	Round yellow globules 3–4 times larger than those of the blood, composed of a thin envelope full of the larger and a few of the largest molecules They are changed but little in water	Yellow round globules 4–6 times larger than those of the blood, composed of a very thin envelope, endowed with the smallest molecules: some have no envelope They swell in water	Round globules 1–3 times larger than those of the blood, composed of the smallest molecules, but seldom of an envelope Are not changed by water

COMPARISON BETWEEN MUCUS AND PUS GENERATED FROM NORMAL INFLAMMATION.

Mucus is composed of

1. Of Globules.
2. Of the thick pellucid ductile fluid.
3. Of Epithelium.

	FORM OF THE GLOBULES.	MAGNITUDE.	COLOR.	ENVELOPE.	CENTRAL VESICLE.	MOLECULES.	DISTILLED WATER.	ACETIC ACID.	OXALIC ACID.	TARTARIC ACID.	NITRIC ACID.	MURIATIC ACID.	SOLUTION OF THE NITRATE OF SILVER.	CONCENTRATED SOL. OF NITRATE OF SILVER.	PURE AMMONIA.	LIME WATER.	PURE POTASH.	SPIRITS OF WINE.
1. Of Globules.	Round	6-8 times larger than those of the blood	White or yellow	Smooth	Single or double	The very small and the larger	Envelopes are broken	Dissolves the envelopes and the very small molecules. — The nuclei 1-6 remain clearly to be seen.	Dissolves the envelopes and the very small molecules	Quickly dissolves the envelopes, the white vesicle remaining.	Corrugates the envelopes	Corrugates the envelopes	Corrugates the globules, and tinges them of a yellow color	First dissolves the envelopes, more slowly the very small molecules and nuclei	No change	No change	Dissolves the globules; the white mucous fluid remains	Contracts the globules
2. Of the thick pellucid ductile fluid.								No change produced	No change produced	No change produced	Forms filaments	Forms filaments		Forms filaments, which are more slowly dissolved in it				
3. Of Epithelium.																		

	FORM OF THE GLOBULES.	MAGNITUDE.	COLOR.	ENVELOPE.	CENTRAL VESICLE.	MOLECULES.	DISTILLED WATER.	ACETIC ACID.	OXALIC ACID.	TARTARIC ACID.	NITRIC ACID.	MURIATIC ACID.	SOLUTION OF THE NITRATE OF SILVER.	CONCENTRATED SOL. OF NITRATE OF SILVER.	PURE AMMONIA.	LIME WATER.	PURE POTASH.	SPIRITS OF WINE.
1. Of Globules. 2. Of a pelluoid fluid.	Round or oblong	3-4 times longer than those of the blood	White or yellow	Smooth or none at all	One or two, seldom none	The very small and the larger	Envelopes are broken	Dissolves the envelopes, the 2-5 nuclei remain	Dissolves the envelopes, the 2-5 nuclei remain	Very quickly dissolves the envelopes	Corrugates the envelopes	Corrugates the envelopes	Corrugates the globules, and gives them a yellow tinge	Renders the globules transparent, the contracted nucleus remaining	No change	No change	Dissolves the globules, the mucous fluid remaining	Contracts the globules, and forms from 1-5 nuclei
3. Sometimes of cells of Epithelium.								Produces no change	Produces no change	Produces no change	Forms no filaments	Forms no filaments	Forms no filaments	Forms no filaments				

CHAPTER XI.

ON MINUTE INJECTIONS.

Mere dissection, with the most artful management of the scalpel, cannot make a full exhibition of the true structure of animal bodies. The arteries are found, after death, to be emptied of their contents, and the blood is coagulated in the veins, which appear much collapsed; hence anatomists, in order to examine the circulatory apparatus, are under the necessity of filling these vessels by means of injection, in order to distend them as much as possible, that their ramifications may be clearly seen. More especially is this necessary when it is desired to make an exhibition of the minute capillaries, which are so variously arranged in the different textures and organs of the body. These small vessels, too, require the aid of the microscope to show their size, form, and arrangement.

The ordinary coarse injection may be made by melting together 16 ounces of bees'-wax, 8 ounces of resin, and 6 fluid-ounces of turpentine varnish, adding such coloring matter as may be desirable, as 3 ounces vermilion, 2 ounces King's yellow, 10 ounces blue verditer, or 5½ ounces flake-white.

This, injected into the blood-vessels by a proper syringe, having its pipe fastened in one of the largest of those vessels, is abundantly sufficient to show the course of the principal arteries and veins. The parts so injected may then be dis-

sected for this purpose, dried, and varnished, and form excellent illustrations of anatomical lectures.

When, however, it is desired to demonstrate the capillaries, a finer injection and more delicate manipulation are required. Indeed, it is so difficult an art, and success is so dependent on the combination of various circumstances, that the most experienced are often defeated in their efforts. Yet some of the finest injections I have ever seen were made by those who attempted it for the first time.

For minute injection (as it is called), the most essential instrument is a proper syringe. This should be made of brass, of such a size that the tip of the thumb may press on the head or handle of the piston-rod when drawn out, while the body is supported by two of the fingers of the same hand.

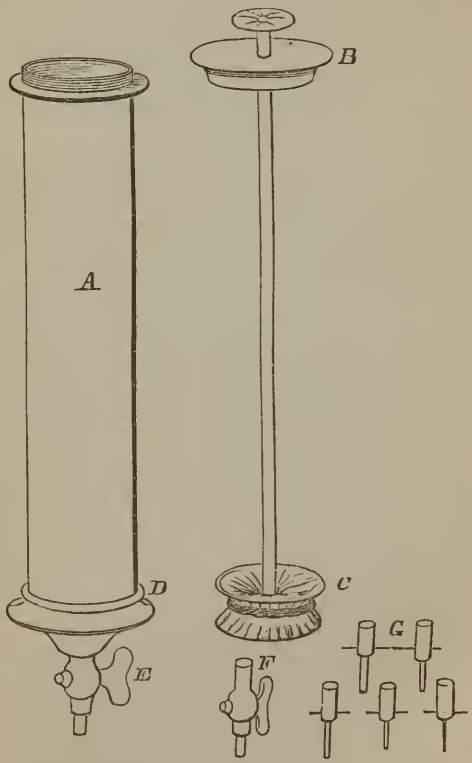
Fig. 50 represents a syringe, with which I have succeeded in making some excellent preparations. A is the cylindrical brass body, on the top of which screws the cap, B, a leather washer being interposed to render it more air-tight. C is the piston, which is of brass, covered with wash-leather. The bottom of the syringe, D, also unscrews, for convenience of cleaning. E is a stop-cock, on the end of which another stop-cock, F, fits closely. On the end of this, one of the injection-pipes, G, which are of different sizes, may be placed. The transverse wires, across the injection-pipes, are designed for the better security of the pipe in the vessel into which it is fixed; the thread being tied behind them so that it cannot slip forwards. A half-dozen pipes, at least, are necessary to accompany each instrument.

In addition to the syringe, a large tin vessel to contain hot water, with two or three lesser ones fixed in it for the injections, will be found useful.

For very minute injections, as in the Mollusca, &c, a caoutchouc bottle, with a capillary steel tube mounted in wood,

ivory, or iron, is recommended by Talk & Henfrey, after Straus Durekheim. The air should be pressed out of the bottle, and

Fig. 50.



the pipe placed in the liquid, which will rush in to fill the vacuum, and it is ready for use. They also recommend a tube, or pipette, with flexible stems, so constructed as to receive jets

of various sizes. This is used by placing the end of the pipette in the mouth, and exhausting the air on forcing the fluid in the vessels.

To prepare the material for injecting:—Take of the finest and most transparent glue, one pound; break it into small pieces, put it into an earthen pot, and pour on it three pints of cold water; let it stand twenty-four hours, stirring it now and then with a stick; then set it over a slow fire for half an hour, or until all the pieces are perfectly dissolved; skim off the froth from the surface, and strain through a flannel for use. Isinglass, and cuttings of parchment make an excellent size, and are preferable for very particular injections.

The size thus prepared may be colored with any of the following:

Red.—To 1 pint of size, 2 ounces of Chinese vermilion.

Yellow.—Size, 1 pint,—chrome yellow, 2½ ounces.

White.—Size, 1 pint,—flake-white, 3½ ounces.

Blue.—Size, 1 pint,—fine blue smalts, 6 ounces.

It is necessary to remember that whatever coloring matter is employed, must be very finely levigated before it is mixed with the injection. This is a matter of great importance, for a small lump or mass of color, dirt, &c., will clog the minute vessels, so that the injection will not pass into them, and the object will be defeated.

The mixture of size and color should be frequently stirred, or the coloring matter will sink to the bottom.

Respecting the choice of a proper subject for injecting, it may be remarked, that the injection will usually go farthest in young subjects; and the more the creature's fluids have been exhausted in life, the greater will be the success of the injection.

Owing to the contraction of the vessels, it is necessary to wait from one to three days after death before attempting the

injection. Yet it should not be deferred so long that the vessels may become softened, or the injecting material will be extravasated.

To prepare the subject, the principal points to be aimed at are to dissolve the fluids, empty the vessels of them, relax the solids, and prevent the injection from coagulating too soon. For this purpose it is necessary to place the animal, or part to be injected, in warm water, as hot as the operator's hand will bear. This should be kept at nearly the same temperature for some time by occasionally adding hot water. The length of time required is in proportion to the size of the part, and the amount of its rigidity. Ruysch (from whom the art of injecting has been called the Ruyschian art) recommends a previous maceration for a day or two in cold water.

When the size and the subject have both been properly prepared, have the injection as hot as the finger can well bear. One of the pipes, G, Fig. 50, must then be placed in the largest artery of the part, and securely tied. Put the stop-cock, F, into the open end of the pipe, and it is then ready to receive the injection from successive applications of the syringe, A. The injection should be thrown in by a very steady and gentle pressure on the end of the piston-rod. The resistance of the vessels, when nearly full, is often considerable, but it must not be overcome by violent pressure with the syringe.

If the resistance suddenly ceases or diminishes, it indicates that some vessel is ruptured, and the process must be stopped. If it happens at the commencement of the operation, and the vessel cannot be tied, the injection has failed.

When as much injection is passed as may be thought advisable, the preparation may be left (with the stop-cock closed in the pipe) for twenty-four hours, when more material may be thrown in.

The first part of the injecting material forming about a third

or fourth part of the whole, should be very fluid, so as to be capable of penetrating the smallest vessels; afterwards the thicker or coarser portion should be thrown in so as to push the first before it.

As the method of injecting the minute capillaries with colored size is often attended with doubtful success, various other plans have been proposed. Ruysch's method, according to Rigerius, was to employ melted tallow, colored with vermilion, to which, in the summer, a little white wax was added.

Mr. Rauby's material, as published by Dr. Hales, was resin and tallow, of each two ounces, melted and strained through linen; to which was added three ounces of vermilion, or finely ground indigo, which was first well rubbed with eight ounces of turpentine varnish.

Dr. Monro recommended colored oil of turpentine for the small vessels, after the use of which he threw in the common coarse injection.

Professor Breschet frequently employed with success milk, isinglass, the alcoholic solution of gum-lac, spirit varnish, and spirit of turpentine; but he highly commends the coloring matter extracted from campeachy, fernambouc, or sandal woods. He says, "The coloring matter of campeachy wood easily dissolves in water and in alcohol; it is so penetrating that it becomes rapidly spread through the vascular networks. The sole inconvenience of this kind of injection is, that it cannot be made to distend any except most delicate vessels, and that its ready penetration does not admit of distinguishing between arteries, veins, and lymphatics." He also recommends a solution of caoutchouc.

Another process, which may be termed the chemical process, was published in the *Comptes Rendus*, 1841, as the invention of M. Doyere, though the credit of first suggesting it is due to Dr. Goddard, of Philadelphia. According to this, an aqueous solution of bichromate of potass is propelled into the vessels; and

after a short time, in the same manner and into the same vessels an aqueous solution of acetate of lead is injected. This is an excellent method, as the material is quite fluid, and the precipitation of the chromate of lead, which takes place in the vessels themselves, gives a fine sulphur-yellow color.

A red precipitate is obtained by iodide of potassium and bichloride of mercury; blue, by the ferrocyanide of potassium and peroxide of iron; &c.

Dr. Goadby has improved upon the process last named by uniting to the chemical solutions a portion of gelatine. The following is his formula, originally published in the London Lancet, and again in the Medical Examiner, March, 1850.

Saturated solution of bichromate of potash, 8 fluid ounces; water, 8 ounces; gelatine, 2 ounces.

Saturated solution of acetate of lead, 8 fluid ounces; water, 8 ounces; gelatine, 2 ounces.

Dr. G. gives the following remarks respecting this process: —"The majority of preparations, thus injected, require to be dried, and mounted in Canada balsam. Each preparation, when placed on a slip of glass, will necessarily possess more or less of the colored infiltrated gelatine (by which, he alludes to the gelatine, colored by the blood, which, together with the acetate of potash resulting from the chemical decomposition, may have transuded through the coats of the vessel), which, when dry, forms, together with the different shades of the chromate of lead, beautiful objects, possessing depth and richness of color. The gelatine also separates and defines the different layers of vessels. By this injection the arteries are always readily distinguishable by the purity and brightness of the chromate of lead within them, while the veins are detected by the altered color imparted by the blood.

"Those preparations which require to be kept wet, can be

preserved perfeetly in my B fluid—speeifie gravity 1·100; the A fluid destroys them.

"I would recommend, that the slips of glass employed for the dry preparation be instantly inscribed with the name of the preparation, written with a diamond, for, when dry, it is very difficult to recognise one preparation from another, until the operator's eye be educated to the effects of this chemico-gelatinous injection. Where so much wet abounds gummed paper is apt to come off.

"When dry, it is sufficient for the purpose of brief examination by the mieroseope, to wet the surface of a preparation with elean oil of turpentine; immediately after examination, it should be put away earefully in a box, to keep it from the dust, until it ean be mounted in Canada balsam.

"Although highly desirable, as the demonstrator of the capillaries of *normal* tissues, I do not think this kind of injection fitted for morbid preparations, the infiltrated gelatine produeing appearances of a puzzling kind, and caleulated to mislead the pathologist.

"In preparing portions of dried, well-injeeted skin, for examination by the microscope, I have tried the effect of dilute nitrie acid, as a eorroder, with very good results. But, probably, liquor potassæ would have answered this purpose better.

"When size injeetion is to be employed, colored either with vermilion or the ehromate of lead, the animal should be previously prepared by bleeding, to empty the vessels: for if they be filled with eoagulated blood, it is quite impossible to transmit even size, to say nothing of the coloring matter. Hence the difficulty of proeuring good injeetions of the human subjeet.

"But with the 'ehemieo-gelatinous' injeetions no sueh preparation is neeessary, and suecess should always be certain, for the potash liquefies the blood, while constant and long-con-

tinued pressure by the syringe drives it through the parietes of the vessel into the cellular tissue. The large quantity of infiltrated blood—the invariable concomitant of my process—characterizes this from all other modes of injecting, and is a distinctive feature of these preparations."

Still another, and in some respects a more certain and convenient plan, has been employed by Dr. Goddard of Philadelphia. It consists in adding a quantity of sulphuric ether to the finely levigated coloring matter, which is also first ground or mixed with linseed oil, in the manner employed by painters. Upon this plan (as well as upon the last named) I have succeeded in making some beautiful injections of the smallest capillaries, yet I have sometimes failed, owing to the too rapid evaporation of the ether, and the clogging up of the vessels from the early deposition of the solid coloring matter. I have also observed that after the ether has evaporated from the vessels, the particles of coloring material cohere with too little tenacity, so that on putting a section of injected tissue into turpentine, &c., the color has been washed out from the cut ends of the larger vessels. Perhaps a solution of gum mastich, &c., in ether, colored with fine vermilion, &c., will answer the indications better.

Whatever mode of injection be adopted, it is important that the operator be supplied with sufficient material. The quantity which can be used will surprise any one unaccustomed to the process.

A fœtus may be injected by the umbilical vein; a uterus, by the hypogastric arteries; the head, by the carotids; the liver, mucous membrane of the intestines, &c., by the portal vein; an extremity, by the principal artery; &c.

The liver, kidney, &c., may be well injected out of the body; and it is often desirable to use various colors for the different sets of vessels. It will require some practice, however, to judge

how much pressure is necessary to fill but a single set of vessels. After injection, a considerable time must be allowed for drying. Thin slices may then be cut off, and mounted either in balsam or fluid.

The villi of the intestines are beautifully exhibited after injection. They should be macerated a little while in water, or washed with a syringe, to remove the epithelium and mucus. Animals that feed chiefly on vegetables have longer villi than others.

The lungs may be injected by the pulmonary artery or vein. In a fœtus, however, all the organs may be injected from the umbilical vein. The author's injections and specimens of injected lungs confirm the view of Mr. Rainey, that the essential and only true organs of the aeration of the blood are the pulmonary capillaries.

Injections of the skin may be made by the vein of an extremity. They may then be mounted in fluid, or after drying, sections may be made and put up in balsam.

The vessels of the choroid membrane and ciliary processes of the eye are often injected in a fœtus; or in the case of an animal, as a cat, rabbit, &c., injected from the heart. The preparation should be kept in fluid.

Many parts, after injection, require to be macerated in water, or corroded by dilute muriatic acid, &c., in order to exhibit the ramifications of the small vessels. They should be very carefully handled, or moved, in the macerating liquor, as the slightest force may break the vessels. When corroded, the pulpy flesh is to be carefully washed away by placing it under a stream of water, flowing very slowly; or by the use of a syringe with water.

The lymphatics are usually injected with quicksilver, but M. Rusconi and Professor Breschet, have abandoned this method for the colored material, on account of the mercury fre-

quently rupturing by its weight the thin, lymphatic vessels and reservoirs. The first-named gentleman, in his researches on the lymphatics of reptiles, employs in place of the usual injecting tube of Walter (used with the mercury), a small silver syringe, together with a kind of trocar, of which the canula is formed from the quill of the wing-feather of the quail or partridge, the trocar being a tolerably large-sized needle, the point of which has three facets. When desirous of injecting the lymphatic system of a lizard, tortoise, &c., he remarks:—"I seize with a small pair of forceps the mesentery, close to the vertebral column, where the reservoir of the chyle is situated, and I introduce into it the point of the trocar; I then retain the quill and withdraw the needle from the tube. This done, I seize with the small forceps the quill, and introduce into it the small extremity of the syringe, and push the piston with a force always decreasing." He recommends colored wax, mixed with nut-oil, for the injection.

CHAPTER XII.

EXAMINATION OF URINARY DEPOSITS.

The chemical composition of the urine and urinary deposits has within a few years past attracted much attention, and has contributed much to our knowledge respecting the nature of diseases and their diagnosis. To examine these, the microscope is often an essential instrument.

Deposits of *uric acid* and its combinations (called red, or yellow-sand sediments), occur in fever; acute inflammation; in rheumatism; in phthisis; in all the grades of dyspepsia; in all or most stages of diseases attended with arrest of perspiration; in diseases of the genital apparatus; from blows and strains of the loins; from excessive indulgence in animal food; or from too little exercise.

The deposition of *earthy phosphates* (white deposit), should be regarded as of serious importance, always indicating the existence of important functional, and frequently of organic disorder. According to Dr. Bird, they always exist simultaneously with a depressed state of nervous energy, often general, rarely more local, in its seat.

Deposits of oxalate of lime are regarded by Dr. G. Bird as by no means so rare as is generally supposed. He believes that it owes its origin to sugar, and is caused by derangement of the digestive organs.

The urine may contain all or any of the elements of the

blood. The serum may be effused alone, or be accompanied with the red globules.

Whenever the elements of blood appear in the urine, there is ample proof of the existence of active or passive hemorrhage of the kidneys, or urinary tract.

Albuminous urine occurs in Bright's disease, dropsy after scarlatina, &c.

Pus is met with in the urine as the result of suppuration of the kidney, or of some part of the genito-urinary mucous membrane, or of abscesses of the neighboring viscera, opening into the urinary passage.

The presence of *sugar* is not uncommon in dyspepsia, and when excessive is diagnostic of diabetes mellitus.

Kiestein is a whitish, greasy, opalescent pellicle, sometimes found on the urine of pregnant women.

To examine urinary deposits with the microscope, allow the urine to stand; decant the supernatant fluid; pour the remainder into a watch-glass; draw off the small quantity of fluid remaining after a short repose, by means of a pipette; and then place it on the stage of the microscope. When, however, it is necessary to use high powers, a drop of the sediment should be placed on a glass slide and covered with thin glass.

If it is desired to mount the object for future examination, it can be covered, when dry, with a drop of Canada balsam, and surmounted with the thin glass. Very transparent objects should be kept in fluid, as weak spirit, water saturated with creasote, or Goadby's fluid.

Healthy Urine holds in solution a variety of substances, both organic and inorganic. Chemists have not yet succeeded in insulating all its ingredients for examination, but the most important of its solid materials are urea, uric acid, hippuric acid, vesical mucus and epithelial debris, animal extractive, ammoniacal salts, fixed alkaline salts, and earthy salts.

The amount passed by an individual during each twenty-four hours, varies from twenty to fifty ounces, holding in solution from six hundred to seven hundred grains of solid matter. When kept for some time it gradually becomes turbid, and deposits a sediment of earthly phosphates, previously held in solution by the slight excess of acid present. If kept still longer, it gradually putrefies, and, becoming concentrated by evaporation, deposits small crystals of chloride of sodium, phosphates, and other salts, and eventually becomes covered with a grayish-colored mould.

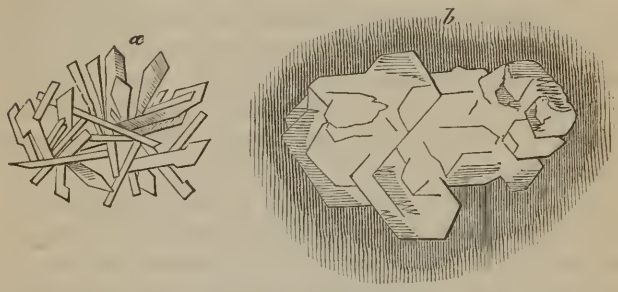
Urea appears to be the vehicle by which nearly the whole of the nitrogen of the exhausted tissues of the body is removed from the system. The proportion of urea in healthy urine averages fourteen or fifteen parts in the one thousand. Pure urea may be obtained by first converting it into the oxalate, which is done by adding a strong solution of oxalic acid in hot water, to urine previously concentrated to about one-eighth its bulk, and filtered to free it from the insoluble sediments of phosphates and urates. The crystal of oxalate of urea thus obtained, *a*, Fig. 51, should be dissolved in hot water, and the solution treated with pulverized chalk as long as effervescence is produced. The urea remains in solution, and may be purified by boiling with animal charcoal, after which it may be crystallized, in four-sided prisms, by careful evaporation.

Nitrate of urea may be obtained in crystals, *b*, Fig. 51, by concentrating urine to about one-half its bulk, and adding an equal quantity of nitric acid. If urea be suspected in excess, a drop of the urine, without concentration, may be treated with nitric acid under the microscope.

The proportion of *uric acid* in the healthy secretion varies from 0·3 to 1·0 in 1000 parts. Its forms will be represented when we treat of the examination of urinary deposits. It may be obtained from urine concentrated to half its bulk, by adding

a few drops of hydrochloric acid, and allowing it to stand a few hours in a cool place.

Fig. 51.



Hippuric Acid is generally present in a small quantity in healthy urine, and in certain forms of disease, especially where a vegetable diet has been adopted. Fig. 52 represents some

Fig. 52.



of its forms; *a* are deposited from an alcoholic solution, and *b* from a hot aqueous solution.

When an excess is suspected in urine, it should be evaporated to the consistence of syrup and mixed with half its bulk of strong hydrochloric acid. After a few hours the crystals

may be examined with the microscope, when the tufts will probably be seen, colored pink by the admixture of purpurine. If it be present only in small quantity, a few detached needle-like or branched crystals may be seen. It is readily soluble in alcohol and hot water, but not in cold water.

Vesical Mucus and *Epithelial Scales*, which may be present, are derived from the internal surface of the bladder and urinary passages. The quantity is so small in healthy urine as to be scarcely visible, until, after standing, it has subsided to the bottom of the liquid in the form of a thin cloud.

Extractive Matter, includes all the uncrystallizable organic matter found in the residue of evaporated urine, which is soluble in water or alcohol. When in excess, the urine appears more highly colored than usual, a large proportion of what is termed extractive, consisting of coloring matter, as purpurine, &c.

Ammoniacal Salts appear to consist chiefly of the muriate and the urate, the latter salt being the form in which the uric acid present in the urine appears to be held in solution.

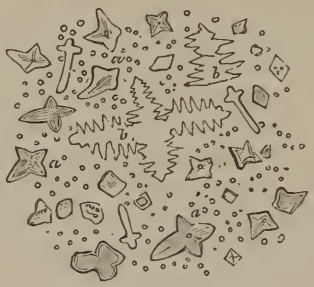
The proportion of ammonia in healthy urine is quite small, but in some diseases, especially in certain kinds of fever, it increases considerably.

Fixed Alkaline Salts may be obtained by incinerating the evaporated residue of urine, when a white ash will be left, consisting of a mixture of alkaline and earthy salts; the former may be separated from the latter by dissolving in water, in which the earthy salts are insoluble.

The alkaline salts, which in the healthy secretion usually amount to thirteen or fourteen parts in one thousand, consist of the sulphates of potash and soda, chloride of sodium, chloride of potassium, and phosphate of soda. The crystallized residue, after slowly evaporating a few drops on a piece of glass, usually has the appearance represented in Fig. 53. The cross-

lets consist of chloride of sodium; the more plumose crystals are probably phosphate of soda.

Fig. 53.



The Earthy Salts which form the insoluble portion of the ash, and which usually amount in healthy urine to about 1 part in 1000, consist of the phosphates of lime and magnesia, together with a small trace of silica. These appear to be retained in solution in the urine by the small excess of acid (probably phosphoric) usually present, and may be precipitated from it by supersaturating with ammonia. The precipitate thus formed consists of a mixture of phosphate of lime, and the double phosphate of ammonia and magnesia, which is also called triple phosphate. These, with the abnormal ingredients found in morbid urine, &c., will be treated of when we come to the examination of urinary deposits. It must be borne in mind, however, that a spontaneous precipitate of earthy phosphates is not of itself a proof that they are present in excess, for when the urine is acid, as in health, a considerable quantity may be retained in solution, while if it be neutral or alkaline, a comparatively small proportion may be precipitated.

When urinary deposit is examined with the microscope, it will be found either *crystalline*, *amorphous*, or *organized*. When, as is frequently the case, the deposit consists of a mixture of different forms, each of them in succession should be examined, until the nature of the whole deposit is clearly understood.

Crystalline Deposits will probably be either uric acid, phosphate of lime and magnesia (from which the triple phosphate is formed), oxalate of lime, or perhaps cystine.

Triple Phosphate.—This salt (called also the double phosphate of ammonia and magnesia) is formed by supersaturating with ammonia. Phosphate of lime is also precipitated by the same means, but may be distinguished by the microscope. The crystals of the triple phosphate are stellate or triangular prisms, as seen in Fig. 54. They disappear on the addition of acetic acid.

Uric (or *Lithic*) *Acid.*—This salt, like the earthy phosphates, exists in a small quantity in healthy urine, but as the proportion varies considerably in many forms of disease, its determination when in abnormal quantity affords much assistance in diagnosis.

It is insoluble in alcohol, and nearly so in dilute hydrochloric and sulphuric acid; but it combines with the alkalies, forming salts, which are insoluble or very sparingly soluble in water.

The action of nitric acid upon uric acid is characteristic. It will gradually dissolve it, carbonic acid and nitrogen being given off with effervescence, leaving behind a mixture of alloxan ($C_8 N_2 H_4 O_{10}$), alloxantine ($C_4 H_3 N_2 O_5$), and other compounds. This may be evaporated nearly to dryness, when a red residue will be left, which, when cold, should be moistened with ammonia, which will develope a beautiful purple color, owing to the formation of murexide ($C_{12} N_5 H_6 O_8$).

The crystalline forms of uric acid are various, but appear to be modifications of the rhombic prism.

Fig. 54.

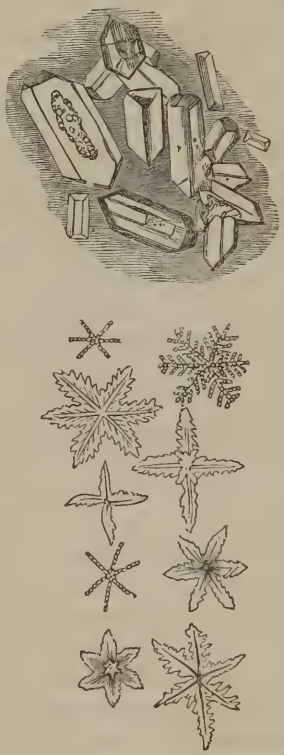
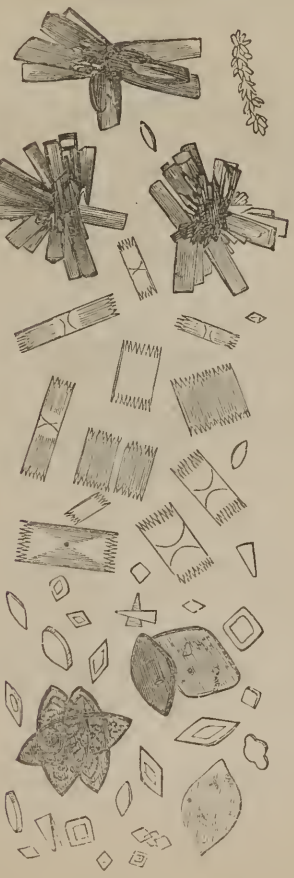


Fig. 55 represents some of its forms.

Oxalate of Lime often exists in the form of minute octahedral crystals, varying from $\frac{1}{750}$th to $\frac{1}{5600}$th of an inch in diameter, *a*, Fig. 56. When allowed to dry on the glass, each

crystal appears under the microscope like a black cube, having

Fig. 55.



in the centre a small white square opening, as shown at *b*.

This is owing to the rays of light being mostly refracted beyond the field of vision. On again moistening them, the crystals reappear in their octahedral form. Sometimes this salt

Fig 56.



assumes the forms represented at *c*, more or less resembling dumb-bells.* This form, like the crystals of uric acid, the

* Dr. Fricke, in the American Journal of Medical Science, July, 1850, states as his opinion that the dumb-bell forms of crystals are not oxalate of lime, but disintegrated crystals of uric acid.

triple phosphate, &c., is beautifully colored when examined by polarized light; the octahedral variety has little or no effect upon it, being invisible, or nearly so, when the field is dark. If the "dumb-bells" are kept in liquid for any length of time, they gradually pass into octahedra.

As the crystals of oxalate of lime are very transparent, and about the same specific gravity as the urine, they may readily escape detection, unless some considerable time is allowed for deposition, or the urine is passed through a filter.

Oxalate of lime is insoluble in water, in acetic and oxalic acids, and in solution of potash; but it is readily soluble in dilute nitric and hydrochloric acids.

Cystine has occasionally been found as a crystalline deposit and in the form of small calculi. It may be distinguished by being insoluble, or nearly so, in water and dilute acids, but soluble in ammonia, from which small hexagonal crystals are deposited on evaporation. The usual microscopic appearance is represented at *a*, Fig. 57. At *b* is the form left from the ammoniacal solution.

Fig. 57.



Amorphous Deposits consist probably of phosphate of lime, urate of ammonia, urate of soda, fat, or chylous matter.

Phosphate of Lime.—This salt has already been described as existing in urine in conjunction with the phosphate of magnesia. It is thrown down, together with the triple phosphate (before

noticed), on the addition of ammonia. The crystalline shape of the triple phosphate, however, readily distinguishes it under the microscope from the amorphous particles of phosphate of lime with which it is usually mixed. The earthy phosphates are readily soluble in dilute acids, from which they are precipitated by ammonia. They are insoluble in a solution of potash.

Urate of Ammonia constitutes one of the most common urinary deposits. It is gradually deposited as the urine cools, in the form of an amorphous precipitate, which, with a high magnifying power, appears to consist of minute rounded particles, occasionally adhering together, frequently mixed with small crystals of uric acid, and occasionally with the earthy phosphates. A deposit of urate of ammonia readily dissolves when the urine containing it is gently warmed, and is precipitated again when the liquid cools. (The earthy phosphates and uric acid are nearly as insoluble in hot as cold water.)

When urate of ammonia is treated with dilute acetic or hydrochloric acid, it is decomposed, and uric acid, is formed.

Urate of Soda is often met with in the urine of patients taking medicinally the carbonate or other salts of soda. It resembles the urate of ammonia in being soluble in hot water, and in most of its chemical characters, but may be generally recognised without difficulty under the microscope, forming minute globular or granular aggregations, with, occasionally, irregular and curved protuberances.

Fat may be recognised by the particles being minute round globules, with dark and well-defined outlines, which dissolve when agitated with ether.

Sometimes this substance is mixed with albuminous matter, forming a kind of emulsion, so that no trace of fat can be perceived with the microscope. In such cases, the urine may be agitated with a little ether, which will dissolve the fat, and

the solution so formed will separate from the watery liquid, and form a distinct stratum on the surface.

Chylous Matter may be known by the urine being opaque and milky in appearance, yielding fatty matter when agitated with ether, and containing minute, amorphous, albuminous particles, and perhaps also colorless globules, which may possibly be mistaken for oil globules, from which their insolubility in ether distinguishes them.

Organized Deposits may either be mucus, usually mixed with epithelium; pus; blood; or semen.

Mucus.—If the particles observed with the microscope are round, or nearly so, and granulated on the surface, entangled in tenacious, stringy masses, which do not break up and mix uniformly with the liquid on agitation, it is probably mucus.

Epithelial debris may be recognised by the peculiar form of its particles. Mucous urine generally contains a considerable amount of earthy phosphates and other matters.

Pus may be known by the particles not being held together by any tenacious matter, but floating freely in the liquid. The granules of pus and mucus present almost the same appearance under the microscope, although the latter may probably be rather smaller and less distinctly granular. Acetic acid renders the interior nuclei visible in both, but it coagulates the fluid portion of the mucus.

Even this test may be uncertain, on account of the dilution of the mucous fluid, and also because the coagulation may have been already occasioned by the presence of the large quantity of water. When the quantity of mucus is abundant, however, this test will be sufficient.

Blood.—When this is suspected in the urine, it may be examined under the microscope for any blood corpuscles that may be in it. If the blood has coagulated, they will probably be entangled in the coagula, and may be forced out by gentle

pressure under a strip of thin glass. If there is no coagula, the liquid may rest for a short time, and a drop from the bottom examined. The urine may also be tested for albumen after separating the solid matter by filtering. When the coloring matter of the blood is present, it will coagulate with the albumen, giving it a red or brown color. When the fibrin, in its soluble form, is present, it usually coagulates spontaneously on cooling, causing the urine to become gelatinous. The coagulum of fibrin, when pressed between glasses, is generally composed of minute amorphous particles, with a few red blood corpuscles, quite different from the granular mucus corpuscles, for which it might be mistaken without microscopic examination.

Bile or purpurine in urine has nearly the same color as when blood is present; hence, unless the blood corpuscles are present, we should apply the tests for the detection of those substances before finally deciding. Purpurine will be dissolved by treating with warm alcohol, or may be precipitated by adding a little warm aqueous solution of urate of ammonia, which on cooling will fall down, carrying with it the coloring matter. Bile may be tested by pouring a few drops of urine on a white plate, and adding carefully a drop or two of nitric acid. When bile is present in any considerable quantity, the liquid becomes successively pale-green, violet, pink, and yellow, the color rapidly changing as the acid mixes with the urine. When only slight traces of bile are present, the urine should be concentrated by evaporation.

When *semen* is present in urine, it may easily be detected under the microscope, by the appearance of minute animalcules, always found in the spermatic fluid, and hence called spermatozoa. They are oval in shape, with long and delicate tails. Traces of albumen may generally be detected in urine containing semen.

Diabetic and Albuminous Urine.—*Albumen* may be tested by boiling the suspected urine gently in a test-tube, when it will be coagulated. As, however, a white precipitate results on boiling, from an excess of earthy phosphate, it will be necessary to add a few drops of nitric acid, which will redissolve the phosphates but leave the coagulated albumen unaffected. Nitric acid also will coagulate albumen. If both heat and nitric acid throw down a white precipitate from urine in separate portions, there can be no doubt of the presence of albumen.

The peculiar casts of urinary tubes found in the urine of patients suffering from Bright's disease, consist of fibrinous or albuminous matter and entangling blood-corpuscles, epithelium, and fatty globules.

Diabetic Sugar has the same chemical composition as that contained in most kinds of fruit, known as grape sugar. Several tests have been proposed for its detection in urine.

Trommer's Test is founded on the circumstance that when a solution of diabetic or grape sugar is boiled with a mixture of potash and sulphate of copper, the oxide of copper contained in the latter is reduced to the state of suboxide, which is precipitated in the form of a reddish-brown or ochre-colored granular powder.

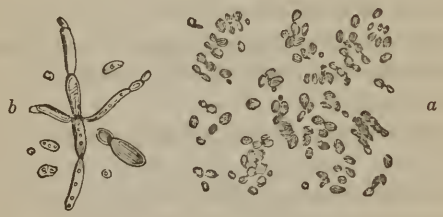
Moore's Test is made by mixing a little suspected urine with half its volume of liquor potassæ and boiling gently for about five minutes. If sugar is present, the liquid assumes a brown or bistre tint.

The Fermentation Test is made by filling a test-tube with the suspected urine, to which a little yeast has been added. The tube is then inverted over a saucer containing some of the urine, and set aside in a warm place for about twenty-four hours. If sugar is present it undergoes the vinous fermentation, by which it becomes converted into alcohol and carbonic

acid. The latter rises in the tube and displaces the liquid. If no sugar be present, no fermentation will take place, and no gas will be formed in the tube.

Test from the Growth of the Torula.—During the process of the vinous fermentation of a liquid containing sugar, a delicate white scum collects on the surface, which when examined with a magnifying power of four or five hundred diameters, will be found to consist of small, oval vesicles, *a*, Fig. 58, which, in

Fig. 58.



the course of a few hours, rapidly change their form, becoming longer and more tubular, and give rise to new vesicles, which shoot out from the parent body, forming an irregular jointed confervoid stem, *b*. These again break up into a great number of oval vesicles, which separate, and fall to the bottom, where they may be detected by the microscope.

The following tables for facilitating the examination of urine and urinary deposits, are modified from Bowman's Medical Chemistry. The reader may also consult the Manuals of Drs. Golding Bird, Griffith, Markwick, and Rees. The works of the latter three gentlemen have been published in Philadelphia, in one convenient volume. The "Analysis" of Dr. Rees contains also a valuable essay on the treatment of urinary diseases.

TABLE I.

FOR THE CHEMICAL EXAMINATION OF URINARY DEPOSITS.

1. The sediment dissolves when warmed. *Urate of Ammonia.* in Urinary Calculi.

2. Not soluble when warmed, but soluble in acetic acid. *Earthy Phosphates.*

3. Insoluble in acetic, but soluble in dilute hydrochloric acid. *Oxalate of Lime.*

4. Insoluble in dilute hydrochloric acid. Purple with nitric acid and ammonia. *Uric Acid.*

If neither of these, it may be,

5. Greenish-yellow deposit, easily diffused on agitation. *Pus?*

6. Ropy and tenacious. *Mucus?*

7. Red or brown; not soluble when warmed; the fluid portion coagulable by heat and nitric acid. *Blood?*

8. Soluble in ammonia; the solution leaving, on evaporation, hexagonal crystals. *Cystine?* In Urinary Calculi.

9. Yellowish sediment, soluble when warmed. *Urate of Soda?*

10. Ether yields, after agitation, an oily or fatty residue. *Fatty Matter.*

11. Milky appearance. *Chylous Matter.*

TABLE II.

FOR THE EXAMINATION OF THE CLEAR LIQUID PORTION.

1. Crystals with nitric acid. *Excess of Urea.*

2. Fermentation, or Trommer's test. *Sugar.*

3. Precipitate formed on boiling; soluble in nitric acid. *Excess of Earthy Phosphates.*

4. Precipitate formed on boiling; insoluble in nitric acid. *Albumen.*

5. Precipitate formed by nitric acid. *Excess of Uric Acid*, or *Albumen.*

6. Concentrated urine yields needle-shaped crystals with hydrochloric acid. *Hippuric Acid.*

If the urine is highly colored,

7. Dark coagulum formed on boiling. *Blood?*

8. Red color with hydrochloric acid. *Excess of Coloring Matter.*

9. Pink precipitate with warm solution of urate of ammonia. *Purpurine.*

10. Change of color with nitric acid. *Biliary Matter.*

TABLE III.

FOR MICROSCOPIC EXAMINATION OF DEPOSIT.

If Crystalline.

1. Lozenge-shaped, &c. *Uric Acid.*
2. Stellæ, or three-sided prisms (after saturating with ammonia). *Triple Phosphate.*
3. Octahedra, or dumb-bells. *Oxalate of Lime.*
4. Rosette-like tables. *Cystine.*

If Amorphous.

5. Soluble when warmed. *Urate of Ammonia.*
6. Soluble in acetic acid. *Phosphate of Lime.*
7. Yellowish grains. *Urate of Soda?*

8. Round globules with dark edges. *Fatty Matter.*
9. White and milky. *Chylous Matter?*

If Organized.

10. Granulated corpuscles, in stringy aggregations. *Mucus.*
11. Irregularly shaped scales. *Epithelium.*
12. Detached granulated corpuscles. *Pus.*
13. Blood-corpuscles. *Blood.*
14. Spermatozoa. *Semen.*

and its return to the urine in disease is accepted as a sign of convalescence.



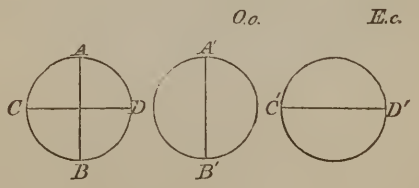
CHAPTER XIII.

ON POLARIZED LIGHT.

"If we transmit," says Dr. Brewster, "a beam of the sun's light through a circular aperture into a dark room, and if we reflect it from any crystallized or uncrystallized body, or transmit it through a thin plate of either of them, it will be reflected and transmitted in the very same manner and with the same intensity, whether the surface of the body is held above or below the beam, or on the right side or left, or on any other side of it, provided that in all these cases it falls upon the surface in the same manner, or, what amounts to the same thing, the beam of solar light has the same properties on all its sides; and this is true, whether it is white light as directly emitted from the sun, or whether it is red light, or light of any other color.

"The same property belongs to light emitted from a candle,

Fig. 59.

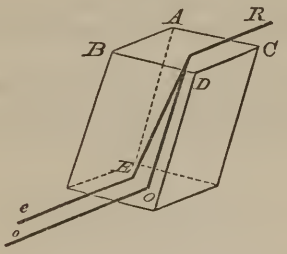


or any burning or self-luminous body, and all such light is called *common* light. A section of such a beam of light will

be a circle, like A, B, C, D, Fig. 59, and we shall distinguish the section of a beam of common light by a circle with two diameters, A B, C D, at right angles to each other.

"If we now allow the same beam of light to fall upon a rhomb of Iceland spar, as in Fig. 60, and examine the two

Fig. 60.



circular beams, O *o*, E *e*, formed by double refraction, we shall find,

"1. That the beams O *o*, E *e*, have different properties on different sides; so that each of them differs, in this respect, from the beams of common light.

"2. That the beam O *o* differs from E *e* in nothing, excepting that the former has the same properties at the sides A′ and B′ that the latter has at the sides C′ and D′, as shown in Fig. 59; or, in general, that the diameters of the beam, at the extremities of which the beam has similar properties, are at right angles to each other.

"These two beams, O *o*, E *e*, Fig. 60, are therefore said to be *polarized*, or to be beams of *polarized* light, because they have sides or *poles* of different properties.

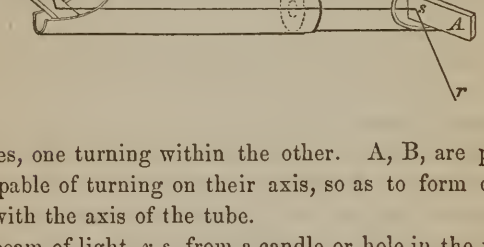
"Now it is a curious fact, that if we cause the two polarized beams, O *o*, E *e*, Fig. 60, to be united into one, we obtain a beam which has exactly the same properties as the beam A, B,

C, D, Fig. 59, of common light. Hence we infer, that a beam of common light consists of *two* beams of polarized light, whose planes of polarization, or whose diameters of similar properties, are at right angles to one another."

There are other means of polarizing light besides that of double refraction, just mentioned. M. Malus discovered, in 1810, that a beam of common light, reflected from glass at an angle of 56°, or from water at an angle of 53° became polarized.

In order to explain the phenomena of polarized light when produced by reflection from glass, let C, D, Fig. 61, represent

Fig. 61.



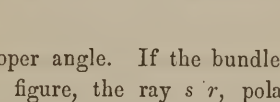
two tubes, one turning within the other. A, B, are plates of glass capable of turning on their axis, so as to form different angles with the axis of the tube.

If a beam of light, *r s*, from a candle or hole in the window-shutter, fall upon A at the polarizing angle of 56° 45′, it will be reflected through the tubes, and will fall upon the second plate, B, also at an angle of 56° 45′. If, however, this plate be so placed that its plane of reflection is at right angles to the plane of reflection of the first plate, A, the ray of light *will not suffer reflection* from B, or will be so faint as to be scarcely visible. If we now turn round the tube, D, carrying the plate, B, without moving the tube C, the reflected ray, E,

will become brighter and brighter till the tube has been turned round 90°, when the plane of reflection from B is coincident with and parallel to that from A. In this position the reflected ray, E is brightest. If the tube be turned again, the light will grow more and more faint, until another 90° are arrived at, when it will again undergo reflection. Thus, changes will take place in every quadrant of 90° until the starting-point is again reached, the ray of light being alternately faint and visible.

The same effect will be produced if we cause a ray of light, R, Fig. 62, to pass through bundles of glass plates, A, B, in-

Fig. 62.



clined at the proper angle. If the bundle of plates, B, be placed as in the figure, the ray *s r*, polarized by passing through the bundle, A, will be incident on B at the polarizing angle, and not a particle will be reflected, but it will be transmitted, as seen at *v w*. If B is now turned round its axis, the transmitted light, *v w*, will gradually diminish, and more and more light will be reflected by the plates of B, till, after a rotation of 90°, the ray, *v w*, will disappear, and all the light will be reflected. Alternate transmissions and reflections will thus take place in every quadrant, as in the former case. For the ray passing through the tube in Fig. 61, or the ray, *s r*, in the last figure, we may substitute one of the polarized rays formed by double refraction in a rhomb of Iceland spar, as seen in Fig. 60, or we may employ with even greater advantage the *single image prism* of Mr. Nicol, who employed a rhomb of calcareous spar divided into two equal portions, in a plane passing through the acute lateral angles, and nearly

touching the obtuse solid angles. The cut surfaces having been carefully polished, were then cemented together with Canada balsam, so as to form a rhomb of nearly the same size and shape as it was before cutting.

By this arrangement, of the two rays into which a beam of common light would be separated, only one is transmitted, the other being rendered too divergent. Two of these prisms form the usual polarizing apparatus of the microscope, being used in the same manner as the bundles of glass plates, Fig. 62, just described. One of the prisms is adapted to the under surface of the stage, and is called the *polarizer;* the other, called the *analyzer*, is placed above the eye-glass.

Dr. Brewster recommends that the analyzing prism be placed immediately behind the object-glass, next the eye, having a rotation independent of the body of the microscope.

Another method of polarizing light, is to disperse or absorb one of the oppositely-polarized beams which constitute common light, and leave the other beam polarized in one plane. These effects may be produced by thin plates of agate, tourmaline, &c.

Many persons employ a thin plate of tourmaline as an *analyzer* in place of a Nicol's prism, and if its color be not objectionable, it may be used to advantage, as the field of view is not so much contracted as when a prism is used. A tourmaline of a neutral tint is an excellent analyzer.

The splendid colors, and systems of colored rings produced by transmitting polarized light through transparent bodies that possess double refraction, are the most brilliant phenomena that can be exhibited. They were discovered simultaneously by M. Arago and Dr. Brewster.

To see these colors:—having the polarizing apparatus so placed that no light can be seen through it, place a thin film of mica or sulphate of lime (between the twentieth and fiftieth

of an inch thick), so that the polarized beam may pass through it perpendicularly. It should be placed between the *polarizer* and the *analyzer*, as on the stage of the microscope. If now the eye is applied to the polarizing apparatus, as before, the surface of the film of sulphate of lime, &c., will be seen covered with the most brilliant colors. If the film be turned round, still keeping it perpendicular to the polarized ray, the colors will become less or more bright, and two positions will be found, at right angles with each other, wherein no colors at all are perceived. If the analyzer be turned round, the film retaining its position, complementary colors will alternate, together with points of invisibility, during each revolution.

The colors of the film vary with its thickness, so that by making grooves or lines of various depths, the most beautiful patterns may be produced. Drawings of figures and landscapes are thus executed, and being mounted between glasses in Canada balsam, are invisible, or nearly so, till exposed to polarized light, when they are seen distinctly, arrayed in most gorgeous colors.

Various crystals exhibit, round their axes of double refraction, beautiful systems of colored rings, often intersected by a black cross. Complementary colors may be produced in them by turning round the analyzer. In large crystals, as rhombs of Iceland spar, certain angles must be ground down and polished in order to exhibit the rings.

In those crystals having two axes of double refraction, a double system of rings will be seen. A transverse section of a prism of nitre will exhibit this phenomenon.

The great advantage of employing the microscope in viewing the colors of crystals, &c., by polarized light, arises from the fact that, when crystallized on a slip of glass, many of the small crystals will be arranged with their axes of double refraction in the direction of the polarized beam. All such,

therefore, will exhibit colors, as will those also in which the thickness of the crystal is not below the proper standard.

After the polarizing apparatus is adjusted, as before described, the crystals properly mounted may be placed on the stage, in the same way as ordinary objects. Some few vegetable structures may be exhibited in the same manner, as the siliceous cuticle of equisetum, starch, &c. Many animal structures, as feathers, slices of quill, horn, &c., are best shown by placing a film of selenite or mica beneath them, by which they become intensely colored. If the film be of unequal thickness, the colors will vary,

"The application," says Mr. Quekett, "of this modification of light to the illumination of very minute structures has not yet been fully carried out, but still there is no test of differences in density between any two or more parts of the same substance that can at all approach it in delicacy. All structures, therefore, belonging either to the animal, vegetable, or mineral kingdom, in which the power of unequal or double refraction is suspected to be present, are those that should especially be investigated by polarized light. Some of the most delicate of the elementary tissues of animals, such as the tubes of nerves, the ultimate fibrillæ of muscle, &c., are amongst some of the most striking subjects that may be studied with advantage under this method of illumination."

To prepare Crystals for Polarized Light. — Pour a few drops of a saturated solution of the salt on a glass slide, gently warm it over a spirit lamp, so as to evaporate the excess of fluid, taking care not to apply too much heat, lest the water of crystallization be driven off and the salt become opaque. The more slowly the crystallization is effected, the better.

The crystals should then be examined, and the best of them mounted, either in the dry way (interposing a cell of paper,

&c., to preserve them from injury by the pressure of the glass cover), or in Canada balsam. If it be desired to examine the crystals during their formation, the crystallization should be carried on in a glass that is slightly concave. All those crystals that are so thin as not to exhibit color, may have color given them by placing a film of mica or selenite under them on the stage of the microscope.

According to Mr. Fox Talbot, who first applied the microscope to the examination of polarized light, sulphate of copper, crystallized from a solution to which a little nitric ether has been added; oxalate of chromium and potash, from an aqueous solution; and borax, crystallized in dilute phosphoric acid, are especially beautiful.

CHAPTER XIV.

MISCELLANEOUS HINTS TO MICROSCOPISTS.

On Cleaning the Glasses.—"When you clean the eye-glasses (a point of great importance to pure vision), do not remove more than one at a time, and be sure to replace it before you begin another; by this means you will be sure to preserve the component glasses in their proper places; recollect that if they become intermingled, they will be useless. Keep a piece of well-dusted chamois leather, slightly impregnated with some of the finest putty or crocus powder, in a little box to wipe them with—for it is of consequence to preserve it from dust and damp; the former will scratch the glasses, and the latter will prevent you from wiping them clean. As to the object-glasses, endeavor to keep them as clean as possible without wiping, and merely use a camel's-hair pencil to brush them with; for wiping them hard with anything has always a tendency to destroy their adjustment, unless they are firmly burnished into their cells."—*Dr. Goring.*

On Stopping False Light in Microscopes.—This is one of the most important requisites in an instrument; for however perfect it may be, if there is the least light reflected from the mountings of the glasses, or within the tubes, the fog and glare produced will materially deteriorate their performance; it is therefore necessary that all their surfaces be made as sombre as possible. The usual method of effecting this is to cover the parts while hot with a black lacquer, made by mixing lamp-

black in a solution of shell-lac in strong spirits of wine. A more elegant method, and better suited for delicate work, is to wash the surface, previously freed from grease and tarnish, with a solution of platina in nitro-muriatic acid (chloride of platinum); after remaining on the work a few minutes it is wiped off, the surface having assumed a deep brown or black color. If these are not at hand, a strong solution of muriate of ammonia will answer for temporary purposes. Another method of stifling false light is by stops or diaphragms in the body of the instrument; these have already been referred to.

Cabinet for Microscopic Objects.—The author of "Microscopic Objects" recommends a cabinet with shallow drawers —twelve of them occupy a depth of four and a half inches—the most convenient width from front to back being six inches. Into these shallow drawers the slides containing the objects are laid flat in double rows. The outer ends of the slides are made to fit into a ledge in the front and back of each drawer. The inner ends of the slides meeting in the middle of the drawer are kept down by a very thin slip of wood covered with velvet. In this way the slides do not shake when the cabinet is moved from place to place; every object is seen without removal, and no loss of time is occasioned in making a selection.

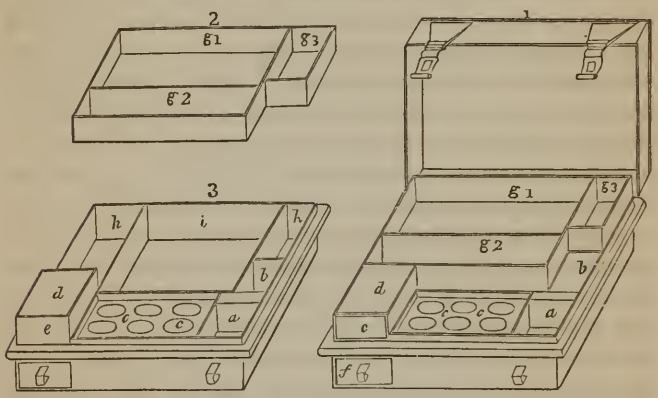
Some persons have their slides arranged edgewise, in boxes made in imitation of books; the ends of the slides being held by a sort of rack. This sometimes may be convenient, but the other form is preferable.

Goadby's Manipulating Box.—This is an exceedingly neat and useful article, represented by Fig. 63. No. 1, represents the box when open, No. 2, a movable tray of peculiar form, and No. 3, the box with No. 2 removed.

"No. 1.—*a*. Compartment to receive a bottle, 2 inches square, 3¼ high, to the top of the stopper, for preserving fluid.—*b*.

Space reserved for the spirit lamp.—*c*, *c*. A shelf of tin, perforated with six holes, to receive three stoppered, two-drachm bottles, for liq. potassæ, sulphuric acid, camphene (or turpentine), and

Fig. 63.



three glass jars, 2⅝ths high, ⅞ths diameter, made out of stout glass, without a lip, and fitted with corks, for Canada balsam, prepared asphaltum, lamp-black and gold size.—*d*. A slab of porcelain, 2⅜ths square, resting upon a tin frame, and carried up so as to be flush with the level of all the bottles, and the tray (2), when in its place. Beneath the slab is *e*, a drawer, 2⅜ths long, 2¼ wide, and ¾ths deep, to hold about three dozen of the smallest slides I use, viz., 2⅛th by ¾ths. Beneath *e* is a deep well, which occupies the space from the drawer *e* to *f*, another drawer, which runs the whole length of the box, from front to back; it has the width and depth of *e*.

No. 2.—g^1. This compartment of the tray measures 8 inches long, 2½ *full* wide, 1¼ deep. It contains the iron plate, its brass legs, and mahogany stand; a small cutting-board, kept for thin glass only, measuring 6 inches by 2⅜ths, ⅛th thick, fur-

nished with a guide-board 5 inches long, ½ inch wide, and ⅛th thick, and a gauge, 6 inches long, nearly ⅝ths wide, and ⅛th thick. A card-board box, 2½ by 1¾ths, and ⅞ths deep, to hold plates of thin glass; the small brass square, already described; mahogany square, 6 inches by 2½, ⅛th thick; a number of badger's-hair pencils in handles.—g^2. Glazier's diamond; scratch do.; marine glue (cane) brush; knife and engraver's tool for cleaning cells; small glass mules to grind the black cement on the porcelain slab, and sundry glass (dropping and other) tubes.—g^3. Pill-box with whiting; white wax for thread; cotton-wool; sundries.

No. 3.—*h*. A fixed tray, 4 inches by 2½, and ¾ths deep, to contain glass for covers to larger cells.—*i*. A well, 5½ by 4 inches, 1½ *full* deep, to hold spare slides of the larger size, with or without cells cemented to them, spare cells, &c.—*k*. A supply of the finest and other varieties of China three twist; pill-box containing small pins, so necessary in dissecting; pill-box containing cells cut in the *thinnest* glass.—Drawer *f*, contains several small palette-knives, in ivory handles, for mixing the cement on the slab; the blades differ in length from 1¼ to 3⅛th, and from ⅛th to ⅜ths at the point; drills for glass and many little things. Below the shelf *c c*, is a similarly perforated shelf, raised somewhat from the bottom, the design being to grasp the bottles at two points. Should the bottles not be sufficiently high to occupy all the depth allowed for them, they must be raised by a shelf of tin, the intention being, that when the box is closed, everything should be more or less pressed upon and kept in its place. The whole is japanned dead black within, and lustrous black without."

Brewster's Method of Illuminating Objects.—Considering a perfect microscope as consisting of two parts, viz., an illuminating apparatus, and a magnifying apparatus, Sir D. Brewster states, that it is of more consequence that the illumi-

nating apparatus should be perfect, than that the magnifying one should be so; and the essential part of his method consists in this:—That the rays which form the illuminating image or disk shall have their foci exactly on the part of the microscopic object to be observed, so that the illuminating rays may radiate as it were from the object, as if it were luminous. Now this can only be well attained by illuminating with a single lens, or a system of lenses, without spherical or chromatic aberration, whose focal length, either real or equivalent, is less than the focal length of the object-glass of the microscope. The smaller the focal length of the illuminating lens, or system of lenses, the more completely do we secure the condition, that the illuminating rays shall not come to a focus, either before they reach the object, or after they have passed it.

Mode of Obtaining the Wheel Animalculæ (*Vorticella rotatoria*).—"Early in the spring I fill a three-gallon jug with pure rain-water (not butt-water, because it contains the larvæ of the great tribe). This quantity more than suffices to fill a half-pint mug, and to keep it at the same level during the season. I then tie up a small portion of hay, about the size of the smallest joint of the little finger, trimming it so that it may not occupy too much room in the mug, and place it in the water; or about the same quantity of green sage leaves, also tied and trimmed. About every ten days I remove the decayed portion with a piece of wire, and substitute a fresh supply. A much greater number of animalcules are raised by the sage leaves; but I have sometimes been obliged to discontinue the use of it, on account of its producing mouldiness. I take them out with an ear-picker, scraping up the sides of the mug near the surface (including the dirt which adheres to them by the tail), or under the hay or sage."—*J. Ford.*

Substitute for the Concave Speculum.—Mr. G. Jackson employs a plano-convex lens of about two inches in diame-

ter, and of four and a half inches focus, silvered on the plane slide, and backed with a plate of brass. This lens, when so treated, becomes a reflector of about two and a quarter inches focus, and forms one of the best instruments that can be desired for throwing light upon an object viewed as opaque. We have used such arrangement for some time in place of the concave mirror, and deemed it peculiar to ourselves till reading an account of the above.

Apparatus to Prevent the Evaporation of Liquids under the Microscope.—Vapors arising from the liquids under observation would, by condensing on the under surface of the object-glass, form there round drops, which act as so many lenses, and which, arresting the rays of light in their progress, would scatter them in every direction, and thus completely destroy the image before it could reach the object-glass. This effect takes place not only when the temperature of the liquid is raised by the application of heat, either directly or in consequence of chemical action, but also when, in studying any body by the microscope, a fuming acid is used, such as the hydrochloric. This inconvenience is prevented by enclosing the frame of the object-glass in a small glass tube, shut at one end, whose inner surface is closely applied to the surface of the object-glass. This end is then plunged into the liquid, which is thus prevented from either beclouding the surface of the lens or finding its way into the interior of the microscope and there producing the same effect.—*Raspail's Organic Chemistry.*

Dropping Tubes, for placing on the object-holder or slide any reagent whose action is to be examined, may be easily made by softening a piece of glass tube in the flame of a lamp, and drawing it out till it becomes capillary, after which it may be broken to a convenient length. Fishing-tubes for animalculæ may also be made in the same way.

INDEX.

A.

PAGE

Achromatic object-glasses, their invention an epoch in histology, 18
description of, . . . 34
comparison of different makers, 38
Animal tissues, to be examined when fresh, . . . 17
on procuring, ... 81
Accessory instruments, ... 41
Animalculæ cage, ... 37, 49
Asphaltum cement, ... 60
Agate, ... 67
Algæ, ... 77
Aphides, ... 90
Acari, ... 90
Anatomical preparations, ... 94
Areolar tissue, ... 103
Artificial star, as a test object, ... 111
Angle of aperture, explained, ... 112
Arm rests, ... 120
Albuminous urine, ... 170, 183
Alkaline salts in urine, ... 173
Advantage of polarized light in examination, . . . 193
Apparatus to prevent evaporation, ... 201

B.

Bog iron ore, from infusoria, ... 14
Borelli, his observations on pus, &c., . . . 15
Blood corpuscles, ... 95

PAGE
Blood disks of siren, ... 95
Bone, ... 97
Basement membrane, ... 104, 131
Bat's hair, ... 114
Branchial cartilage of tadpole, ... 135
Blood in urine, ... 169, 181
Bile in urine, ... 182
Brewster's mode of illuminating objects, . . . 199

C.

Causes of error in observation, ... 15
Coal beds, from vegetation, ... 14
Coddington lens, ... 29
Compound microscope, ... 31
defects of the common, . . . 33
improvements in the, . . . 33
mechanical conveniences necessary to the, 35
forms of the, ... 36
most celebrated makers of the, . 36, 38
Smith and Beck's, . . . 36
efforts to reduce the price of the, . 38
Condenser, ... 41, 53
for oblique illumination, . . . 42
Condensing (or bull's eye) lens, ... 44, 52
Camera lucida, ... 37, 47
Compressorium, ... 50
Cook's preserving fluid, ... 56
Cooper's preserving fluid, ... 56
Cells for mounting, ... 59
Cements, ... 60
Canada balsam cement, ... 61
Charring vegetable matters, ... 61
Carbonate of lime, ... 67
Crystallization of salts, ... 67
water, ... 68
Cuticles, ... 69
Cellular tissues, ... 70

PAGE
Charcoal, ... 73
Circulation in vegetables, ... 78
Corals, ... 86
Circulation of blood, ... 96
Capillaries, their functions, ... 106
of skin, ... 100, 109
of mucous membrane, . . . 105, 109, 167
Crystalline lens in fish, ... 101
Ciliary processes of the eye, ... 101
movement, ... 105
Chromatic aberration, ... 33
mode of observing, . . . 110
Circulatory system of insects, ... 126
Chemical constitution of organized bodies, . . . 130
Cell-growth in a meliceritous tumor, ... 137
Classification of animal tissues, ... 136
malignant growths, ... 142
Carcinoma, ... 143
Chemico-gelatinous injection by Dr. Goadby, . . . 164
Cystine in urine, ... 179
Colors exhibited by polarized light, ... 192
Cleaning the glasses of microscopes, . . . 196
Cabinet for microscopic objects, ... 197

D.

Dissecting microscope of Mr. Slack, . . . 27
Dark wells, ... 38
Diaphragm, ... 37, 41, 51, 53
Deut-ioduret of mercury, ... 68
Dissecting needles, ... 119
troughs, ... 120
Digestive system of insects, ... 125
Development of cells, ... 131
animal tissues, ... 134
Diabetic urine, ... 170, 183

E.

PAGE
Erector, ... 44
Entozoon folliculorum, ... 91
Epithelium, ... 104
Examination of morbid structure, ... 139
its importance, . . 141
Encephaloid, ... 146
Earthy phosphates in urine, . . . 169, 171, 174
Eyes of animals, ... 101

F.

Fossil remains determined by the microscope, . . 14
Fontana, histological observations of, ... 17
Frog plate, ... 47
Fishing tubes, ... 49, 201
Fossil wood, ... 73
Ferns, ... 77
Fibrous and areolar tissue, ... 103
Forms of nuclei, ... 133
Form of fibrous tumor, ... 141

G.

Geology, use of microscope in, ... 13
Goadby's fluids, ... 57
manipulating box, ... 197
Gum mastich cement, ... 60
Glycerine, ... 56

H.

Histology, created by the microscope, . . . 14
Hewson on the blood globules, ... 17
Herschell's doublets, ... 29
Holland's triplet, ... 31
Huygenian eye-piece, ... 35
Hairs, down, &c., of plants, ... 73

PAGE
Hard tissues, ... 76
Hair of animals, ... 93
Horn, hoofs, quills, &c., ... 94
Human blood, ... 94
Hair of Dermestes, ... 114
Hippuric acid, ... 172

I.

Importance of the microscope to zoology, . . . 14
Inorganic objects, ... 67
Illuminating lamp, ... 45, 52
Iron pyrites, ... 68
Infusoria, classification of, ... 81
on procuring, ... 83
to observe the structure of, . . . 85
fossil, ... 85
Insects, antennæ of, ... 86
eggs, ... 87
elytra, ... 88
eyes, ... 88
feet, ... 89
hairs, ... 89
mouths, &c., ... 90
parasitic, ... 90
trachea, ... 91
stings, ovipositors, &c., ... 91
internal anatomy of, ... 123
Injected papillæ of skin, ... 99, 109
preparations, ... 106
Instruments for minute dissection, ... 118
Internal anatomy of insects, ... 123
Injecting materials, ... 158, 161, 163
Instrument for diagnosis of tumors, . . . 148
Injection of the lymphatics, ... 167

J.

Japanner's gold size, ... 60

K.

PAGE
Kiestein, ... 170

L.

Lenses, different forms and effects of, . . . 22
simple mode of making, ... 28
imperfections in, ... 29
Lewenhoeck, his discoveries, ... 16
Lieberkuhn, his anatomical researches, . . . 17
concave reflector, so called, . . . 46
Lamp-black cement, ... 61
Lichens and fungi, ... 77
Loaded corks, ... 120
Lepisma saccharina, ... 115

M.

Malpighi, microscopic researches of, . . . 15
Modern observers, ... 19
Medico-legal inquiries with the microscope, . . 21
Micrometer eye-piece, ... 35
stage, ... 48
Magnifying powers, hints respecting, ... 51
table of, ... 23
to obtain the power of a compound microscope, ... 48
Mirror, use of the, ... 52
Management of the light, ... 52
Mounting transparent objects, ... 55
in the dry way, . . . 55, 56, 63
in fluid, ... 58
in balsam, ... 61
Marine glue, ... 60
Mounting cellular structures, ... 62
opaque objects, ... 64
crystals for polarized light, . . . 66, 194
Mosses, ... 76

PAGE
Muscular fibre, ... 101
Mucous membrane, ... 104
Mouse hair, ... 114
Morpho Menelaus, ... 115
Muscular system of insects, ... 128
Morphology of pathological fluids, ... 149
Method of injection, by Ruysch, ... 163
Rauby, ... 163
Monro, ... 163
Professor Breschet, . . 163
M. Doyere, ... 163
Dr. Goddard, . . . 163, 166
Mucus in urine, ... 181

N.

Nervous structure, examination of, ... 102
Nerves and capillaries of muscle, ... 102
Nervous system of insects, ... 126

O.

Organic remains in limestone, ... 14
Optical illusion to be guarded against, . . . 17
Opaque objects, mounting of, ... 64
how viewed, ... 53
Mr. Brooke's mode of viewing, . . 46
Oolites, ... 68
Organic fibres, ... 77
Oxalate of lime in urine, ... 169, 176, 185

P.

Polarizing apparatus, ... 43
Preparation of glass slides, ... 56, 58
Preserving fluids, ... 56
Pollen, ... 74
Pigment cells of skin, ... 100
of the eye, ... 101

PAGE
Pontia brassica, ... 116
Podura plumbea, ... 116
Proximate principles, ... 130
Primary form of organic matter, ... 130
Pus in urine, ... 170, 181
distinction between it and mucus, . . . 139
Polarization of light, ... 188

Q.

Qualifications of a microscopist, ... 18

R.

Religious sentiment, microscope conducive to, . . . 13
Reflecting microscope superseded, ... 39
a curious form of, ... 39
Rules for microscopic observations, . . . 51
Raphides, ... 76
Retina of the eye, ... 101
Respiratory system of insects, ... 123

S.

Simple microscopes, construction of, . . . 23
magnifying powers of, . . . 23
mode of mounting, . . . 23
form of, for opaque objects, . . 26
Stanhope lens, ... 29
Silver cup or Lieberkuhn, ... 37, 46
Side reflector, ... 37, 46
Stage micrometer, ... 48
Size of glass for mounting, ... 55
Sealing-wax varnish, ... 60
Sand, ... 68
Sections of granite, &c., ... 68
coal, ... 68
wood, ... 72
Siliceous cuticles, ... 73

PAGE
Starch, ... 74
Seeds, ... 76
Sponges, ... 86
Shells of mollusca, ... 91
Scales of fish, ... 92
Skin, ... 99
Spherical aberration, ... 33, 110
Scales of insects, ... 115
Shells of infusoria, ... 85, 116
Swammerdam's scissors, ... 118
mode of dissection, ... 121
Secondary organic compounds, ... 130
Scrofulous growths, ... 142
Syringe for minute injection, ... 159
Stopping false light in microscopes, ... 196
Substitute for the concave speculum, . . . 200

T.

Trough for chara, &c , ... 37, 50
Thin cells for delicate tissues, ... 59
Teeth, ... 98
Theory of life and sensation, ... 106
Test objects, Dr. Goring's discovery of, . . . 110
character of, ... 114
Tinea vestianella, ... 115
Tables for examination of urinary deposits, . . 185
of results of Dr. Gruby's observations, . . . 149

U.

Utility of the microscope in medicine, . . . 19
Urinary deposits, ... 169
Urea, ... 171
Uric acid, ... 169, 171
Urate of ammonia, ... 180
soda, ... 180

V.

PAGE
Vegetable physiology, microscope indispensable in, . 14
Varley's dark chamber, ... 42
Vegetable tissues, dissection of, ... 69
Vascular tissue in plants, ... 72
Vitality and electricity not identical, . . . 108
Valentin's knife, ... 119
Vital principle, theories respecting the, . . . 106, 129

W.

Withering's Botanical Microscope, ... 23
Wilson's Pocket Microscope, ... 24
Wollaston's doublet, ... 30
condenser, ... 42
Watch-glasses useful, ... 49
White fibrous tissue, ... 103
Wheel animalculæ, mode of obtaining, ... 200

Y.

Yellow fibrous tissue, ... 103

Z.

Zoophytes, ... 86

THE END.

LINDSAY & BLAKISTON'S PUBLICATIONS.

MORFIT'S CHEMICAL AND PHARMÆCEUTICAL MANIPULATIONS,

WITH

Four Hundred and Twenty-three Illustrations.

A MANUAL OF THE MECHANICAL AND CHEMICO-MECHANICAL OPERATIONS OF THE LABORATORY;

CONTAINING A COMPLETE DESCRIPTION OF THE MOST APPROVED APPARATUS, WITH INSTRUCTIONS AS TO THEIR APPLICATION AND MANAGEMENT, BOTH IN THE MANUFACTURING PROCESS AND IN THE MORE EXACT DETAILS OF ANALYSIS AND ACCURATE RESEARCH.

BY CAMPBELL MORFIT,

Practical and Analytical Chemist; Author of "Applied Chemistry," &c. &c.

ASSISTED BY ALEXANDER MUCKLE,

Chemical Assistant in Professor Booth's Laboratory.

IN ONE VOLUME, OCTAVO.

Extract of a Letter from Prof. J. C. Booth, Practical and Analytical Chemist.

"I regard it as a very valuable addition to a Chemical Library, whether to that of an experimental or manufacturing chemist; for, while the business of the former is wholly experimental research, the latter is frequently forced to enter into the same field, in order to improve his processes. Although I have been a witness of the author's untiring industry in preparing this work, yet, upon examining it in its present state, I am surprised to find it so complete in all its parts. I know that there is a large amount of original matter contained in it, the result of the author's observation and experience; and that which has been derived from other sources, has been judiciously and harmoniously culled from a very extensive Chemical Library. I therefore think that every one connected with Chemistry, in any of its numerous departments, should have a copy of this work in his library. I intend using it freely in my course of instruction in Experimental Chemistry, and shall recommend it to my students."

This work is one that ought to be in the hands of every student of Pharmacy and Chemistry. It contains a variety and amount of information for which he will seek in vain in any of the professed treatises on Chemistry. The author has had in his mind the admirable treatise of Professor Farraday, and has given in a condensed form nearly all that is valuable for ordinary use in that work, besides much original matter, and much collected from other sources—all of which has been rendered far more useful and intelligible by the aid of excellent illustrations.—*American Journal of Pharmacy.*

To every one who desires to become familiar with the operations of the laboratory, or with those of physical science in general, we recommend this work, as it will be found upon trial to recommend itself strongly. It contains descriptions of the newest apparatus, the most approved method of research, and the most recent results of scientific investigation, in place of old and exploded utensils, modes, and tables, and is well worthy of adoption in all laboratories of instruction.—*Journal of the Franklin Institute.*

LINDSAY & BLAKISTON'S PUBLICATIONS.

A Valuable Work for Druggists, Manufacturers, &c.

The Druggist's General Receipt Book,

BY HENRY BEASLEY.

CONTAINING NUMEROUS RECIPES FOR PATENT AND PROPRIETARY MEDICINES, DRUGGIST'S NOSTRUMS, ETC. FACTITIOUS MINERAL WATERS, AND POWDERS FOR PREPARING THEM

ALSO,

NUMEROUS RECIPES FOR PERFUMERY, COSMETICS, BEVERAGES, DIETETIC ARTICLES, AND CONDIMENTS, TRADE CHEMICALS, MISCELLANEOUS COMPOUNDS, USED IN THE ARTS, DOMESTIC ECONOMY, ETC. ETC.

WITH MANY OTHER USEFUL TABLES AND MEMORANDA.

ALSO,

A COPIOUS VETERINARY FORMULA AND MATERIA MEDICA, &C.

NOTICES OF THE PRESS.

This work has been prepared by one whose previous publications give evidence of his ability to do so. The work must be very useful to practical chemists and druggists, and may not be without its advantage in private families, living remote from medical aid, or where the ordinary articles of medicine in use in families may not be always accessible. The work is handsomely printed, and well bound; and, from the extensive range it takes, must find large numbers who will have constant use for it.—*Baltimore Patriot.*

Druggists will find this an invaluable manual, and many others engaged in every other occupation, will find it a convenient and valuable guide in the preparation of various articles for the sick room, the toilet, or the table. It is a most thorough and carefully-prepared work.—*Evening Bulletin.*

An indispensable manual to many traders, manufacturers, and dealers generally, containing the receipts for a great variety of articles; and, of course, to test their adulteration. The veterinary department is full; the chapters on patent medicines, distilled preparations, and trade chemicals, contain much information not only for special use, but for profitable consideration by the community at large.—*Literary World.*

A useful work, designed to enlighten the public mind upon a variety of matters which have generally been beyond access to the people. It will also prove serviceable to professional men, druggists, and others.—*Baltimore Sun.*

CHEMICAL ANALYSIS, QUALITATIVE AND QUANTITATIVE.

BY HENRY M. NOAD,

LECTURER ON CHEMISTRY AT ST. GEORGE'S HOSPITAL.

Author of "Lectures on Electricity," "Lectures on Chemistry," &c.

WITH NUMEROUS ADDITIONS,

BY CAMPBELL MORFIT,

PRACTICAL AND ANALYTICAL CHEMIST;

Author of "Chemical and Pharmaceutic Manipulations," and co-editor of the "Encyclopedia of Chemistry."

WITH ILLUSTRATIONS,

IN ONE VOLUME, DEMY-OCTAVO.

The scientific reader will find in this volume an amount of information not to be found elsewhere in a form so convenient and accessible. Mr. Morfit has added to it much original matter, especially with reference to the latest investigations in chemical analysis. The arrangement of the volume, which contains nearly six hundred pages, is such as to give it all the value of an encyclopedia, so far as to afford easy reference to any one branch or topic.—*Commercial Advertiser.*

This is a work of great accuracy and research; and with Mr. Morfit's additions, is a complete manual both of qualitative and quantitative analysis, in organic and inorganic chemistry. This, and Mr. Morfit's "Chemical and Pharmaceutical Manipulations," noticed not long since, are indispensable manuals for all engaged in experimental and manufacturing chemistry; and are, indeed, valuable auxiliaries even to those engaged in experimental research. It has numerous tables and other illustrations, and is printed and bound in a style that does much credit to the publishers.—*Saturday Courier.*

The importance of analytical chemistry as a handmaid to the arts, is a sufficient reason why we should hail with pleasure the publication of works devoted to that branch of science. We believe that, if for no other reason than the ability it confers of detecting adulterations, apothecaries should give a portion of their time to acquiring a knowledge of analysis. The book before us is one of several that have been published on the subject, and treats of it in a manner calculated to facilitate the labours of the student. Several additions have been made by the American editor, to improve the work, and bring it down to the time of publication.—*American Journal of Pharmacy.*

M'ALLISTER & CO.,

No. 48 Chestnut Street, Philadelphia,

HAVE FOR SALE A VERY LARGE ASSORTMENT OF

COMPOUND MICROSCOPES.

Neatly mounted in Brass, of a power ranging from 15 to 60 diameters, from $2 50 to $10

An Achromatic Microscope, cylinder brass body, with rack-work and condenser—power fifty times. Price, $16 00

Ditto, with power of 120 to 135 times, $22 and $23

A still better Microscope, also Achromatic, to screw upon top of the box, which makes it firmer—large stage, rack-work, condenser, dissecting instruments, &c.—power 120 times. Price, $26 00

The same instrument, with extra Lenses, so as to increase the power from 160 to 250 times. Price, $33 00 to $37 00

The very best Achromatic Microscopes, with movable lever or rack-work stage—Microscope to be placed either vertical or horizontal—bull's eye condenser—frog-plate, &c.; cost from $150 to $650

Sets of Achromatic Lenses, of various powers, separate from the Microscopes, $4 50 to $9 00 per set.

Eye-pieces, of various powers, separate from the Microscopes, $2 25 to $3 00 each.

Glass slips for Microscopic slides or preparations, 50 cts per doz.

Glass dishes and covers for Microscopic slides, and wet preparations, $1 25 to $3 00 per doz.

Thin glass for covering Microscopic objects.

Microscopic sliders, in sets of 12, 24, and 36, of portions of insects, sections of wood, guano, feathers, &c. Prices from $2 to $6 50 the set.

Finely prepared objects, parts of insects, &c., 19 to 50 cents each.

" " " anatomical as injections, 75 cents each.

Also, Magnifying Glasses, in horn cases, for the pocket; Microscopes to examine the ear; Urinometers, Thermometers, Hydrometers, Weighing Scales, Magnets, Mathematical Instruments, Spy-Glasses; Camera Lucidas, Stanhope Lenses, &c.

Z. 48755-50

L 5394

-ob.—25-

L.S.F.
recat